Vol. 13. Parts 7-9. Pp. 91-134, 1 pl. 25th October, 1938.

THE PROCEEDINGS
OF THE
ROYAL ENTOMOLOGICAL SOCIETY OF LONDON

Series A.
GENERAL ENTOMOLOGY

World list abbreviation: *Proc. R. ent. Soc. Lond.* (A)

CONTENTS

PAGE

Brindley, Mrs. Maud D., F.R.E.S. The metathoracic postcoxal bridge of Heteroptera . . . . 103–106, 1 fig.

Carpenter, Prof. G. D. Hale, F.R.E.S. Two remarkable cases of beak-marks on butterflies 101–102

Carpenter, Prof. G. D. Hale, F.R.E.S. Detached wings of the Saturniid *Nudaurelia tyrrhea* Cr. (Lepidoptera) . . . 102

Edelsten, H. M., F.R.E.S. Microlepidoptera. Recent additions to the British list exhibited on behalf of the Department of Entomology, British Museum (Natural History) . . . 97–98

Edelsten, H. M., F.R.E.S. Notes on Lepidoptera exhibited . 98

Evans, A. C., F.R.E.S. Studies on the distribution of nitrogen in insects. II. A note on the estimation and some properties of insect cuticle 107–110

Fraenkel, G., Ph.D., and Harrison, J. L. Irregular abdomina in *Calliphora erythrocephala* (Mg.) . . . . 95–96, 3 figs.

Hawkins, C. N., F.R.E.S. Insect teratology . . . . . 92–94, 1 fig.

Hobby, Dr. B. M., M.A., D.Phil., F.R.E.S. *Ancistrocerus parietinus* L. (Hym., Vespidae) and *Chrysis ignita* L. (Hym., Chrysididae) bred from cells constructed between book and bookcase 100

Nash, T. A. M., F.R.E.S. Caterpillars crossing a railway track in Nigeria 99

Potter, Mrs. Edith, Ph.D., F.R.E.S. The internal anatomy of the larvae of *Panorpa* and *Boreus* (Mecoptera) . . . . 117–130, 12 figs.

Slifer, Eleanor H., and Uvarov, B. P., D.Sc., F.R.E.S. Brunner's organ; a structure found on the jumping legs of grasshoppers (Orthoptera) . . . . 111–115, 1 pl.

Turner, H. J., F.R.E.S. Notes on some Lepidoptera . . . 91

Book Notices 91, 99, 100, 110, 116, 130–134

LONDON:
PUBLISHED BY THE SOCIETY AND
SOLD AT ITS ROOMS, 41, QUEEN'S GATE, S.W.7
Price 9s. 0d.

THE ROYAL ENTOMOLOGICAL SOCIETY OF LONDON

Founded, 1833. Incorporated by Royal Charter, 1885.

PATRON—HIS MAJESTY THE KING.

OFFICERS and COUNCIL for the SESSION 1938–1939.

J. C. F. Fryer, O.B.E., M.A., *President.*

H. M. Edelsten
A. D. Imms, M.A., Sc.D., F.R.S. } *Vice-Presidents.*
H. Willoughby Ellis, M.I.E.E.

Francis Hemming, C.M.G., C.B.E., *Treasurer.*

O. W. Richards, M.A., D.Sc., *Secretary.*

F. J. Griffin, A.L.A., *Registrar.*

Other Members of Council.

R. B. Benson, M.A.
Brig.-Gen. B. H. Cooke, C.M.G., C.B.E., D.S.O.
C. N. Hawkins.
L. G. Higgins, M.A., F.R.C.S.
B. M. Hobby, M.A., D.Phil.
Sir Guy A. K. Marshall, C.M.G., D.Sc., F.R.S.
N. D. Riley.
W. H. T. Tams.
W. R. Thompson, Ph.D., D.Sc., F.R.S.
B. P. Uvarov, D.Sc.
V. B. Wigglesworth, M.A., B.Ch., M.D.

Trustees of the Society.

R. W. Lloyd.
Sir Edward B. Poulton, F.R.S.

Finance and House Committee.

H. Willoughby Ellis, M.I.E.E. (Chairman).

Prof. P. A. Buxton, M.A.
Brig.-Gen. B. H. Cooke, C.M.G., C.B.E., D.S.O.
G. Fox-Wilson.
C. N. Hawkins.
R. W. Lloyd.

Publication Committee.

W. R. Thompson, Ph.D., D.Sc., F.R.S. (Chairman).

H. E. Andrewes.
M. Burr, D.Sc., F.G.S., A.R.S.M.
B. M. Hobby, M.A., D.Phil.
N. D. Riley.
V. B. Wigglesworth, M.A., B.Ch., M.D.

Library Committee.

R. B. Benson, M.A. (Chairman).

E. A. Cockayne, M.A., M.D., F.R.C.P.
H. M. Edelsten.
B. M. Hobby, M.A., D.Phil.
W. H. T. Tams.
B. P. Uvarov, D.Sc.

Committee for the Protection of British Insects.

W. G. Sheldon (Chairman).

Capt. E. Bagwell-Purefoy.
C. L. Collenette.
W. J. Dow.
J. C. F. Fryer, O.B.E., M.A.
Col. F. A. Labouchere.
N. D. Riley.
H. M. Edelsten (Secretary).

The Executive Officers of the Society are *ex-officio* members of all Committees.

DELEGATES OF THE SOCIETY TO:

1. **British National Committee for Biology** (Royal Society).
   Sir Thomas Hudson Beare, LL.D., F.R.S.E., appointed 1933.
   Karl Jordan, Ph.D., F.R.S., appointed 1936.
2. **Conference of Delegates of Corresponding Societies of the British Association for the Advancement of Science.**
   W. H. Thorpe, M.A., Ph.D., appointed 1938.
3. **International Congress of Entomology** (Berlin 1938).
   J. C. F. Fryer, O.B.E., M.A. *Francis Hemming, C.M.G., C.B.E.*
   A. D. Imms, M.A., Sc.D., F.R.S.
4. **Local Committee of Management of Wicken Fen.**
   H. M. Edelsten. *E. C. Bedwell.*
   [Delegates nominated by Committee for the Protection of British Insects.]
5. **National Trust for Places of Historic Interest or Natural Beauty.**
   W. G. Sheldon, F.Z.S., appointed 1922.
6. **New Forest Association.**
   W. Fassnidge, M.A., appointed 1934.
7. **Royal Meteorological Society. Phenological Committee.**
   C. B. Williams, M.A., Sc.D., appointed 1937.

NOTES ON SOME LEPIDOPTERA EXHIBITED BY H. J. TURNER, F.R.E.S.

1. A recently recognised aberration of the Noctuid *Leucania impura* Hb. In this specimen a jet-black line has developed below the apex of the fore-wing and parallel with the costa. It was sent me by Capt. Parsons of Torquay from that district, and it is proposed to record it under the descriptive term *nigrolinea* (1938, *Ent. Rec.* **50** : 22).

2. Another Noctuid of which a series was bred by Capt. Parsons is a very dark blackish-brown example of *Anchoscelis lunosa* Haw. [ab. *intensa*, 1938, *Ent. Rec.* **50** : 22], with very dark smoky hind-wings and devoid of the light veining so characteristic of most specimens of this species. It is much darker than the form *agrotoides* Gn. which has the light veining on a black-grey ground with a light narrow band along the outer margin and only dark blotches on a light ground on the hind-wings.

3. A few examples of the imperfectly known Pierid form, *dubiosa* Röb., which has been variously assigned to *Pieris rapae* L., *P. napi* L., *P. ergane* Hb.-Gy., *P. manni* Mayer, etc. Information is sought on these specimens.

4. A good series of another local race in the much-discussed *Polyommatus coridon* Poda complex, from Montarco, near Madrid, and which has been named and described as *arragonensis* subsp. *bolivari* Romei.

5. An album with a large number of pencil and colour drawings of ova, pupa and larvae executed by the artist H. Knight some 40 years ago, for the late Dr. T. A. Chapman, F.R.S., some of which had been published in that author's work, " The Genus *Acronycta*," and in the *Trans. ent. Soc. London*, was also exhibited.

BOOK NOTICE.

Pests of ornamental garden plants. By G. FOX-WILSON. pp. 128, 112 figs. 8vo. London, 1937. (H.M. Stationery Office, *Bull. Ministry Agric. Fish.* **97**.) Price 3*s*. 6*d*.

This Bulletin is issued in stiff boards which will protect the book against hard usage.

It includes chapters on control measures, general pests and the pests of individual gardens or parts of gardens, such as lawns, rock gardens, the glass-house, and so on. An index to pests is given.

Details of the various methods of control are given, and the pests described are not restricted to insects, but include all the invertebrates likely to be met with in an ornamental garden.

INSECT TERATOLOGY

By C. N. Hawkins, F.R.E.S.

1. An example of spiral segmentation in the larva of the Geometrid moth, *Lycia hirtaria* Clerck.

On 27th June 1936 several normal larvae of this species were found on poplar at Wandsworth Common. From them, normal imagines were bred in 1937, including a male and a female which emerged on 19th April. The latter were placed together in a cardboard box so formed that at each corner there was a double thickness of card not too tightly fastened together, so that the female could insert her ovipositor between the two layers of card and lay her eggs in the crannies. Pairing duly took place and a large number of ova were laid between the layers of card from the 22nd to the 24th April. The ova hatched on the 21st and 22nd May. As the species is usually so common round London, no particular care was taken but so soon as it was seen that hatching had begun, the inner pieces of the double card, where they covered the ova, were bent back and, if ova were attached, the pieces were cut off. Other ova were removed by shaving off the surface of the card, taking the batch with it, others dropped off and some were destroyed by crushing etc. A good many ova and young larvae were turned out in the garden but a certain number were kept for breeding experiments. Those that were kept were put into a glass-topped metal box with the necessary food supply, and all except one were perfectly normal. When small, these larvae spin a considerable amount of silk, and are apt to become entangled if care is not taken. One day when removing the old food I found a small larva, about half grown in the 1st stadium, between two leaves the inner surface of which it had evidently been eating. Although so small, this larva was behaving in such an unusual manner, being apparently quite unable to walk but just wriggling about without progressing, that it attracted my attention. I then discovered that it had spiral segmentation and that the fore part of the body was so twisted over to the left, or, rather, so revolved on its longitudinal axis, that its true (thoracic) legs were about at right angles to its prolegs and that in consequence when it stretched out to walk in the usual Geometrid manner, it could get no grip with its true legs so long as its prolegs retained their hold. I replaced it between two leaves (which seemed the only way it could hope to feed) in a separate box and for a day or two all went well. Unfortunately, however, it became so hopelessly entangled in its own silk that it could no longer move, and in trying to release it I accidentally killed it. By this time it was about full grown in its 1st stadium and I placed it in spirit to await description. Since then it has become somewhat shrunken but owing to its pattern the spiral is plainly visible under a lens in spite of the small size of the larva, now about $\frac{3}{32}$ inch long. In its 1st stadium the larva of this species has a striking pattern, the ground colour being dark grey-brown with cream-coloured markings. The latter, so far as material to the present purpose (they exist elsewhere also), consist of transverse bands or lines situated towards the posterior border of the 1st, 2nd, 3rd, 4th and 5th abdominal segments. These cross bands are dorsal and lateral only; they are absent on the ventral surface. They are composed of oblong streaks or dashes, and small oval spots, of cream colour, thus contrasting strongly with the dark ground colour of the young larva and indicating the spiral segmentation very clearly. As this specimen

PROC. R. ENT. SOC. LOND. (A) 13. PTS. 7–9. (OCT. 1938.)

is so very small I have made a diagrammatic sketch under a magnification of about 30 diams., which will assist the description that follows. As will be seen, the spiral is a right-handed dorsal one, involving the 1st, 2nd and 3rd abdominal segments. The left tergite of the 1st abdominal segment is shortened to the centre line of the dorsum so that it forms a triangle, the left tergite of the 2nd abdominal segment is inclined forward so that it meets the right tergite of the 1st abdominal, the left tergite of the 3rd abdominal appears to be lengthened towards the centre line, and so does the right tergite of the 2nd abdominal which meets it, and the right tergite of the 3rd abdominal is shortened to the centre line so that, like the left tergite of the 1st abdominal, it forms a triangle. Two of the cream-coloured spots on the right tergite of the 1st abdominal are duplicated (a glance at the sketch will make the position, etc., of these double spots clear), but I am not at all sure of the significance of this. Unfortunately the larva is now so wrinkled that I cannot make out the arrangement of the setae, even under a fairly high magnification, so I must omit any further reference to them. This appears to be only the second record of spiral segmentation in a Geometrid larva, the first being a *Lygris pyraliata* (Fab.), described by Dr. E. A. Cockayne in 1934, *Trans. ent. Soc. Lond.* **82** : 171. In the circumstances, so many ova and 1st stadium larvae having been turned out, there is no certainty that the *L. hirtaria* larva described was the only abnormal one in the brood, but having regard to the treatment of the ova in moving them from the cardboard box, the possibility, to say the least, of injury to the developing embryo cannot be ignored.

2. Spiral segmentation in a pupa and imago of *Lithophane* (*Xylina*) *socia* (Rott.) (*petrificata* F.).

On 6th June 1934 I exhibited and described a living example of this species showing spiral segmentation (1934, *Proc. ent. Soc. Lond.* **9** : 60), and the object of the present note is to give the subsequent history of that larva and to correct an error in the description. In the hope of being able to obtain definite information as to whether such abnormalities in lepidopterous larvae are inherited or not, I decided to rear this specimen to the imago stage, pair it with a male or female (as the case might require) of the same brood and if possible carry on the strain for at least two more generations. With this object in view, the spiral larva was kept separate from the rest and reared to maturity. It duly pupated and proved to be a female. The imago emerged in August and, of course, both pupa and imago had the same spiral abnormality as the larva. The pupa shows this well, and the accompanying diagrammatic sketch will serve to place it on record. It will be seen that although I originally described the larva as having left-handed spiral segmentation " in " the 1st, 2nd and 3rd abdominal segments, the pupa shows that it is really the 2nd and 3rd segments only which form the actual spiral, though the tergites of the 1st segment are modified to fit the abnormal tergites of the 2nd. The word " in " should have been " affecting." The imago became so damaged and shrunken after laying all her ova that the segmentation is now too obscured for the specimen to be worth exhibiting, but the abnormality is exactly the same as in the pupa. The other imagines of the brood emerged during July and August and two males were put aside to be kept alive with the spiral female. This species hibernates in the imaginal stage and does not pair till the following spring. The three moths were placed in a flower-pot partially filled with dry sandy earth, dried moss and dead leaves, and the whole was covered with lino and placed in a very cool garden shed for the winter. A small piece of sugar was laid upon the lino and this was moistened from time to time with a little water. For a time during the autumn the moths fed at the sugar and water in the evenings but later they settled down to hibernate and hardly moved at all. In the spring they became active again and during the night of the 19th–20th March 1935 the spiral female paired with one of the males. Curiously enough, she had begun to lay a few ova on the 15th March, and it is possible she had paired before, though I believe these early ova were all infertile. However this may be, after the observed pairing, oviposition proceeded regularly on the lino, the sides of the pot, bits of leaf, etc., till some 535 ova had been laid. Nearly all were fertile and the young larvae developed to the hatching point, but for some reason about 100 larvae only actually hatched and many of these died almost at once, apparently without attempting to feed. All the larvae, living and dead, which hatched were examined very carefully but no abnormalities were found. The surviving larvae took to their food satisfactorily and fed well for a time, but they gradually faded away, and although a few reached full growth and went underground for pupation, even forming good cocoons, not one actually pupated and the experiment came to a premature end. The failure of so many of the ova to hatch is puzzling. Possibly there was some inherited lethal factor involved; possibly the ova were kept too dry, although I do not think so; possibly the conditions under which the moths were kept during the winter, and the food (plain sugar and water) with which they were supplied, resulted in a weakening which affected the offspring. There are obviously too many unknown factors to enable any conclusions to be drawn and so the problem still remains to be solved.

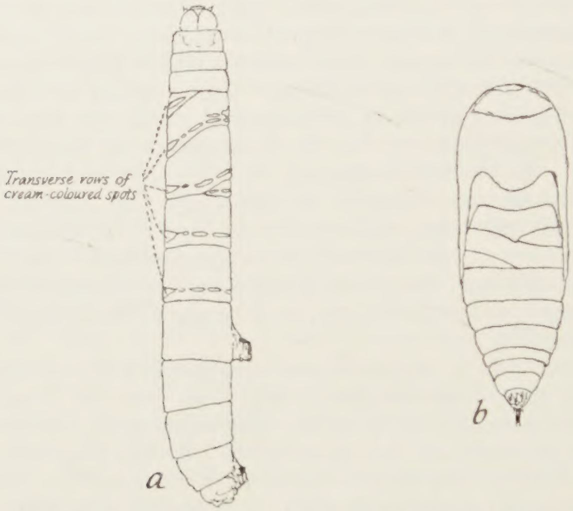


Fig. 1.—a. *Lycia hirtaria* Clerck. 1st stadium larva exhibiting spiral segmentation affecting the 1st, 2nd and 3rd abdominal somites. × 30 diams. approx. (Diagrammatic sketch.) b. *Lithophane* (*Xylina*) *socia* Rott. (*petrificata* F.).—Dorsal aspect of pupa showing spiral segmentation affecting the 1st, 2nd and 3rd abdominal somites. × 4 diams. approx. (Diagrammatic sketch.)

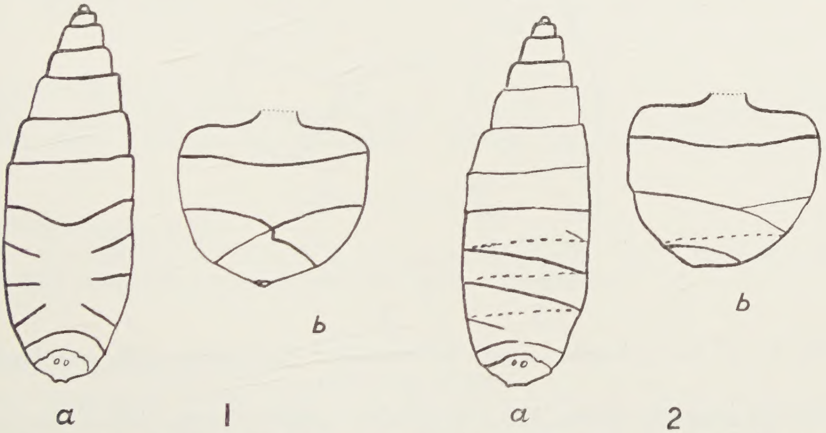
IRREGULAR ABDOMINA IN *CALLIPHORA ERYTHROCEPHALA* (MG.)

By G. Fraenkel, Ph.D., and J. L. Harrison.

Communicated by O. W. Richards, F.R.E.S.

It has been noticed for several years in a mass culture of *Calliphora erythrocephala* that larvae with irregularly segmented abdomina occasionally occur. Whenever these larvae appear a certain number of them is found, *e.g.* 20 or 30 in a batch of, say, 300 larvae. This suggests, strongly, that the irregular ones all come from one female. The irregularities may be classified roughly into three types :

1. Broken segments (fig. 1) : a short interruption in the segmental border.
2. Spiral segmentation (fig. 2) : a segment line starts on the dorsal side near the middle line, and instead of forming a closed ring continues backwards in a spiral, extending over 1, 2 or 3 segments and ending again near the dorsal middle line. In front and behind the spiral the segmentation is normal.
3. Irregular segmentation (fig. 3) : Under this group we place provisionally irregularities of a more complex type than those falling under 1 and 2. This group has not yet been sufficiently analysed, but it appears that the basis of these irregularities is also a spiral structure.



Figs. 1–2.—1. (a) Larva of *Calliphora erythrocephala* showing three " broken " segments; (b) abdomen of the female bred from the preceding. 2. (a) Larva showing spiral segmentation; (b) abdomen of the male bred from the preceding.

When these larvae pupate, exactly the same irregularities are shown on the pupal case. This is to be expected, since the pupal case is identical with the cuticle of the last (3rd) larval instar. The adults also show almost the same types of irregularities as the larvae from which they are derived. There are, however, two modifications :

1. Irregularities affecting the last segments of the larvae are not obvious in the adult because the last segments of the larva go into the formation of the sexual organs of the adult (ovipositor and hypopygium). If these irregularities are shown in the ovipositor and hypopygium, which is likely to be the case, we should have excellent material for identifying the larval segments in these organs.
2. The blind ends of the irregular segment borders tend to join up with

PROC. R. ENT. SOC. LOND. (A) 13. PTS. 7–9. (OCT. 1938.)

other segment borders. This leads to a very irregular mosaic of small segmental areas in the skin of the adult.

Exactly the same types of irregularities have been found and described in the adult *Drosophila melanogaster* Mg., where they are due to one or probably more genes (1919, Bridges and Morgan, *Publ. Carnegie Inst. Wash.*, **278**: 241, footnote, plate 11). The course of heredity in these cases is not yet fully understood.

During November 1937 a batch of 90 larvae was obtained from a stock culture of *C. erythrocephala*, 78 of which were irregular. These 78 larvae were bred out and the flies kept together in a jar. In the course of 3 weeks 6 batches of eggs were obtained from these flies, in intervals of 3 or 4 days. The larvae had the following composition :

1st batch	120 regular larvae	226 irregular larvae
2nd „	10 „ „	212 „ „
3rd „	— „ „	87 „ „
4th „	271 „ „	25 „ „
5th „	37 „ „	2 „ „
6th „	139 „ „	133 „ „
	577	685

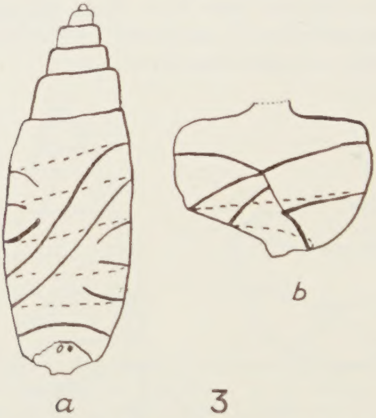


Fig. 3.—(a) Larva showing irregular segmentation; (b) abdomen of the male bred from the preceding.

Of the 685 irregular larvae, 119 were of the "broken" type, 233 of the spiral type and 333 of the irregular type. Breeding was attempted again from both the regular and irregular larvae. But unfortunately, owing to adverse circumstances, no larvae were obtained from the irregular flies, and only two batches, altogether 55 larvae, from the regular ones, none of which proved to be irregular.

From these breeding experiments there can be no doubt that the irregular abdomina in *C. erythrocephala* are hereditary. Nothing about the type of heredity can be said so far except that we probably are not dealing here with a simple Mendelian case. There is a great variability in the "*expression*" (Timofeéff) of the gene, since all the range of irregularities from short interruptions in a segmental border up to very irregular cases obviously have the same genetical origin, and the "*penetrans*" (Timofeéff) is low, which means that the hereditary character, although present genetically, is not always realised externally.

It is intended to develop and extend the analysis of the irregular abdomina of *C. erythrocephala* on a larger basis than has hitherto been possible.

MICROLEPIDOPTERA. RECENT ADDITIONS TO THE BRITISH LIST EXHIBITED BY H. M. EDELSTEN, F.R.E.S., ON BEHALF OF THE DEPARTMENT OF ENTOMOLOGY, BRITISH MUSEUM (NATURAL HISTORY), BY PERMISSION OF THE TRUSTEES

TORTRICIDAE.

Tortrix postvittana Wkr.

A New Zealand species, first bred in this country in 1933, has since established itself in Cornwall on *Euonymus japonicus.*

EUCOSMIDAE.

Ancylis tineana Hubn.

A single specimen taken by Whittle in 1920 and another by Sheldon in 1923 both at Rannock. The larva feeds on hawthorn and aspen in June.

Crocidosema plebeiana Zell.

Taken in Devon by Bankes in October and in Gloucester by Clutterbuck. Not known elsewhere in Britain. The larva feeds on seeds of *Malva* in July.

Argyroploce leucotreta Meyr.

This species was bred in the Museum from an orange sent in from Birmingham. It is an African species and is a pest on peaches and other fruits.

GELECHIIDAE.

Telphusa alburnella Dup.

Many specimens of this species were taken by A. Smith at Strensall, Yorks, in July 1936. Not recorded elsewhere in Britain. Larvae on *Petula* in May.

BLASTOBASIDAE.

Blastobasis lignea Wlsm.

Locally established since 1917 in Lancs and Kent. Larva on yew April–June, also recorded on cotoneaster and bark of sycamore.

OECOPHORIDAE.

Parocystola acroxantha Meyr.

An Australian species taken on the south coast of Devon in August, introduced with Australian trees now locally established. Larva unknown.

NEPTICULIDAE.

Nepticula decentella H.-S.

First recorded from Eastbourne in 1933 and later found in Surrey. The larva feeds on seeds of sycamore in May.

GLYPHIPTERYGIDAE.

Simaethis diana Hübn.

First taken by Mackworth Praed at Fasnakyle, Inverness, in 1919. Not known to occur elsewhere in Britain. Larvae in a web on upperside of leaves of birch in August.

LYONETIIDAE.

Opogona subcervinella Wkr.

Bred from bananas in 1925. The larva is a destructive pest in growing bananas and potato tubers, but is not likely to establish itself in this climate.

GRACILARIIDAE.

Gracilaria azaleella Brnts.

First recorded in Britain in 1926 as a pest in greenhouses where azaleas are grown. The larvae may be found almost all the year round. Probably imported from Japan.

AEGERIIDAE.

Aegeria flaviventris Stdgr.

Taken in Surrey, Sussex, Hants, and Devon in June. Larva in swellings in twigs of *Salix*, August to April.

HYPONOMEUTIDAE.

Hyponomeuta stannella Thnbg.

First recorded by Daltry from Dovedale, Derbyshire, in June 1927. The larvae burrow into roots and stems of *Sedum* in May.

Hyponomeuta rorella Hübn.

This species, known only from Sussex up to 1936, has since been found doing considerable damage to willow in Suffolk. Larva in June.

Ethmia sexpunctella Hubn.

A single specimen taken by Mr. Coney at Dungeness in June 1937. Not recorded elsewhere in Britain. On *Echium* sp.

LAMPRONIIDAE.

Mnesipatris filicivora Meyr.

This species is a recent introduction and is found at present only at Seapoint, Co. Dublin.

The larva feeds on the fronds of a common fern in June and July. It is likely to spread.

NOTES ON LEPIDOPTERA EXHIBITED BY H. M. EDELSTEN, F.R.E.S.

A VARIABLE series of *Oporinia autumnata* Bork. bred from a banded female taken in mid Sussex, some of them being almost unicolorous, while others are banded like the parent.

Oporinia christyi Prout from mid Sussex.

Comibaena pustulata Hufn. The reddish cream-coloured form from mid Sussex.

Epione vespertaria Fb. Aberrations from Yorkshire.

Cephis advenaria Hb. ab. *fasciata* Schwngns. from Yorkshire.

Cucullia verbasci L. A very large heavily marked form with dark hindwings from Sussex.

Lampra fimbria L. Various colour forms from mid Sussex.

Leptologia circellaris Hufn. A male specimen taken at sugar in Sussex, with one of the abdominal brushes withdrawn from its sheath.

Hadena trifolii Rott. A specimen taken at sugar at Wood Walton Fen, Hunts, with clusters of the mite *Cheletomorpha venustissima* Koch on the underside of all four wings.

Cheletomorpha venustissima is usually predacious on other mites. It is not certain whether the specimens shown had attached themselves to this moth for the purposes of transport or in an endeavour to feed upon it. It is usually to be found in old dusty stacks and stables and it is presumed that the moth hid by day in a spot where the mites were unusually plentiful.

CATERPILLARS CROSSING A RAILWAY TRACK IN NIGERIA

By T. A. M. Nash, F.R.E.S.

Communicated by Dr. C. B. Williams, F.R.E.S.

On the afternoon of 27th January, 1938, I was walking along the railway line in a northerly direction from Duchin Wai towards Zaria.

My attention was attracted by countless thousands of dead caterpillars along the track. (I am almost certain that they belonged to the Lasiocampidae.) I was intrigued by what could have caused their death, and during the course of my investigation I made the following observations :—

The bulk of the corpses was piled under the western side of each line. There were only a few under the east side of the left-hand line and none under the east side of the right-hand line. This point is important: I walked over a mile and never saw *a single* corpse under the *east* side of the right-hand line.

I interpret the cause of death to be as follows: An enormous migration of caterpillars was moving along a wide front in an easterly direction. When meeting with the first railway line thousands walked along parallel with the line until exhausted, but some succeeded in crossing this first obstacle. Again the urge eastwards forced the bulk to cross the track until they met the second rail; again thousands crawled along parallel with the track until exhausted, but some managed to get over, and these, still under the impulse to go eastwards, crossed over and disappeared into the bush on the other side. This explanation would account for the complete absence of dead caterpillars on the eastern side of the right-hand line.

I collected some cocoons found under the rails, but doubt if anything will emerge, as the heat under the metal must be tremendous at mid-day. I enclose some dead larvae and cocoons. I am almost certain that this is the same species as one which abounds on the *Isoberlinia dolna* trees.

Book Notice.

Dictionary of scientific terms as used in the various sciences. By C. M. Breadnell. London (Watts & Co.). pp. x + 235. Price 1*s.*

This little book is printed in double column and forms No. 65 of the "Thinker's Library."

Over 6000 terms are explained in a manner suitable to a general reader.

Book Notice.

Les Araignées. Par L. Berland. Paris (Éditions Stock) 1938. 2me Édition. pp. xii + 175. Price 15.00 francs.

The book forms one of a series "Les Livres de Nature" and is addressed to the general reader. It contains chapters on what are Spiders, how they live, where they live, the search for food, silk, poison, courtship, and spiders living in community. Reference is made to the more technical work by the same author, *Les Arachnides* 1932.

ANCISTROCERUS PARIETINUS L. (HYM., VESPIDAE) AND *CHRYSIS IGNITA* L. (HYM., CHRYSIDIDAE) BRED FROM CELLS CONSTRUCTED BETWEEN BOOK AND BOOKCASE

By Dr. B. M. Hobby, M.A., D.Phil., F.R.E.S.

The material was brought to the Oxford University Museum on 29th March, 1938, by Miss B. Bucknall, who stated that the book had been standing in a bookcase in a wooden building at Kennington, Berks. The parent wasp had constructed its cells in the space between the projecting covers of the book, the front edges of its leaves, the back of the bookcase, and the shelf. This space measured 19·5 × 1·0 × 0·5 cm. and contained twelve cells, the first and lowermost flush with the shelf, the twelfth sealed off 6 cm. from the top. In removing the book from the shelf the last five cells and their contents had been destroyed; at this time all the larvae except the first had pupated. Cells 2–7 produced six female *Chrysis ignita* L., the last emerging on 28th April from the uppermost cell. On 30th April a female *Ancistrocerus parietinus* L. emerged from the first cell. *Chrysis ignita* is mentioned as a parasite of *A. parietinus* by A. Schenck (1861, *Jahrb. Ver. Naturk. Nassau*, **16** : 127). I am much indebted to Mr. G. E. J. Nixon for confirming the identifications.

Book Notice.

The Zoology of Iceland . . . managing editors A. Fridriksson and S. L. Tuxen.

Vol. 3. Part 38. Orthoptera and Dermaptera. Price Kr. 0.40.
39. Plecoptera and Ephemeroptera. Price Kr. 0.40.
40. Thysanoptera. Price Kr. 0.60.
53. Opiliones and Chernetes. Price Kr. 0.90.
Copenhagen (Levin & Munksgaard).

These four parts of the *Zoology of Iceland* are all in English, and each forms a separate booklet with a wrapper and is sold separately. A special price is quoted for subscribers to the whole work.

Each part consists of an introduction followed by a synopsis of the species hitherto found or now recorded for Iceland, and general remarks. Each paper is separately paged and further parts are in active preparation.

Book Notice.

Les Cochenilles de France, d'Europe, du Nord de l'Afrique et du Bassin méditerranéen. Par A. Balachowsky. I. Morphologie externe, pp. 68, 1 pl., 40 figs. II. Morphologie interne, pp. 61, 3 pls., 34 figs. (Actualités scientifiques et industrielles 526, 564.) 8vo. Paris (Hermann et Cie.). 1937.

These two paper-covered volumes are devoted to the Coccids of the region detailed in the title. Part I opens with a chapter on the systematic position of the Coccids, followed by consideration of the external morphology of the female (pp. 7–49) and the male (pp. 50–65).

Part II is restricted to the consideration of the internal morphology of the Coccids and includes the Bibliography to both parts.

The work is fully illustrated by line drawings placed in the text.

TWO REMARKABLE CASES OF BEAK-MARKS ON BUTTERFLIES

By Professor G. D. Hale Carpenter, F.R.E.S.

Examination of butterflies for beak-marks has resulted in the discovery of the following two very interesting cases. The first was found by myself in the general collection of the British Museum (Natural History), and I am indebted to the Keeper of Entomology for permission to exhibit and describe it. The second was among unset duplicates in the collection of Dr. A. S. Corbet, who, when I found it, kindly presented it to the Oxford University Museum. Both are of especial interest on account of the number of separate marks, in each case apparently the work of one bird, which show repeated capture and release and, at the same time, remarkably little damage so that after a succession of these experiences the butterfly was still at liberty and was caught by the collector, in one case H. W. Bates. There is no note on this specimen showing any appreciation by Bates of what these marks mean: indeed it is only since Lamborn first pointed it out (1920, *Proc. ent. Soc. Lond.* **1920** : 27) that the real significance has been understood. The fact that these aposematic butterflies were caught and released many times, apparently without suffering any vital damage, is in accordance with the theory which demands that such insects should invite, but be enabled to resist, experimental tasting.

I. *Papilio c. crassus* Cramer, ♂. Pará (*H. W. Bates*).

A fresh specimen. The marks are long, with sides very slightly converging, indicating a long straight beak. Impressions on soft paper of the mandibles of a specimen of Jacamar, *Galbula rufoviridis* Cabanis from the Amazons show that it was probably such a bird that had attacked the butterfly.

There are four separate marks on the right fore-wing.

(1) Stretching right across the wing from the middle of the inner margin, outwards and forwards to the costa at about a quarter of its distance from the tip of the wing. This mark is about 30 millimetres in length.
(2) The most distinct. Commencing on the inner margin, proximal to the tornus, it runs forwards and inwards, across the middle of the cell to the costa.
(3) Faint. From the hind margin at end of vein 2, forwards and inwards to the cell, where it is lost.
(4) Roughly parallel with (3) and proximal to it, its base partly overlapping the base of (2). It runs forwards and inwards, through the proximal half of the cell, to the costa, proximal to (2).

The left fore-wing is more scratched than the right, and beak-marks are not clear: one seems to run from the inner margin near the base forwards and outwards across the base of vein 2; another is suggested by a long mark running from the inner margin, proximal to the tornus, forwards and outwards, parallel with the hind margin. This, however, is not certainly a beak-mark. The right hind-wing, on its under surface, shows a very definite beak-mark, of which no. 2 on the fore-wing is probably the counterpart, the two wings having

PROC. R. ENT. SOC. LOND. (A) 13. PTS. 7–9. (OCT. 1938.)

been seized when the fore-wing was covering the hind-wing. There is a slit at the anal angle and the mark runs forwards and slightly outwards, through the end of the cell, to the costa.

II. *Euploea m. mulciber* Cramer, ♀. Selangor, Sungei Buloh (*A. S. Corbet*), 4.xii.1929.

The specimen is fairly fresh and has suffered little by the repeated attacks: but there is a notch in the margin of the left hind-wing between the ends of veins 4 and 5. The wings of the left side show that a bird seized the insect three times, the imprints, corresponding closely to the beak of a Malayan Bee-eater (form of *Merops leschenaulti* Vieillot), being shown on fore- and hind-wing together. In this case, contrary to the former, the attacks have been from in front, the relatively much broader base of the beak-mark being on the costa of the fore-wing. The four wings were all gripped together by one attack, on the other two occasions only the wings of the left side were gripped.

(1) The proximal mark affects the bases of all four wings. It is more clearly shown on the left side, where it crosses the fore-wing and extends well down the hind-wing, the tip of the beak having rubbed a bare spot at about the middle of the third white radial streak from the anal margin.

(2) External to (1), on the fore-wing running from the costa at the junction of its proximal and middle third outwards and backwards to the middle of the hind margin: on the hind-wing the mark runs from the middle of the costa backwards through the cell to the base of area 2.

(3) External to (2), from the middle of the costa of the fore-wing, backwards and outwards to the inner margin proximal to the tornus. This is a very complete print of the characteristic Bee-eater bill. On the hind-wing it runs almost straight backwards from the anterior angle on the costa to the edge of the notch on the hind margin at vein 4.

DETACHED WINGS OF THE SATURNIID *NUDAURELIA TYRRHEA* CR. (LEPIDOPTERA)

By Professor G. D. Hale Carpenter, F.R.E.S.

The wings were sent by Mr. R. Moreau, from the East African Agricultural Research Station, Amani, Tanganyika Territory, with the following note: "8th March, 1938. I send a number of moth wings, the least damaged of some scores, all belonging to this species, found under an overhanging rock in the side of the Engare Rongai gully on the north slope of Kilimanjaro, at 9500 ft., on 17.ii.38. This is practically the upper edge of tree growth, only a few small *Agauria* persisting so far." The wings bore no evidence of attack by birds, and it is probable that bats were the predators.

Mr. R. J. West kindly identified the wings of this moth in the British Museum.

THE METATHORACIC POSTCOXAL BRIDGE OF HETEROPTERA

By Maud D. Brindley, F.R.E.S.

In the course of a study of the pleuro-sternum of the Heteroptera, it was noticed in the Pyrrhocorid *Dindymus* that two pairs of slender muscles extended from the base of the metathoracic apophyses to the anterior margin of the second (first definitive) abdominal sternum. The thorax of this group, in spite of its specialisation, possesses some generalised characters; and the occurrence of these muscles, now functionless and of doubtful homology, suggested an investigation into this character in other bugs.

The primitive arrangement of the longitudinal muscles of insects seems to have been intersegmental. The fibres rose from each antecosta or intersegmental fold and passed back to the antecosta of the succeeding segment. This condition is still seen in many larvae; but in adult Pterygota the specialisation of the anterior part of the body for locomotion has obscured the original plan; and the principal sternal longitudinal muscles of the thorax have become secondarily attached to the apophyses, which, as invaginations of the sternal plates, are presumably segmental in origin. In most insects the original intersegmental attachment is retained only in the abdomen, although in a few more generalised forms some unimportant muscles still extend between the first two thoracic intersegmentalia or spinae. In every case the intersegmental element behind the metathoracic sternum is obsolete because it fuses with the first abdominal sternum and becomes the antecosta of the latter. For this reason, in most adult insects the longitudinal muscles between the metathorax and the first abdominal sternum are lacking because the fibres from the second spina, where they persist, have formed a secondary attachment on the apophyses and are no longer inserted on the third intersegmental element. The latter has become incorporated with the first abdominal sternum, and from it arise the most anterior of the muscles which constitute the ventral longitudinal system of the abdomen. Hence the segmental sequence of the sternal muscles is broken between the metathorax and the first abdominal segment. The only case recorded to the contrary seems to be that of the Ephemeridae, described by Dürcken (2) where a pair of muscles rise from the base of the metasternal apophyses, and are attached to the anterior margin of the first abdominal sternum. Snodgrass (6) remarks that these muscles may be homologous with a pair of muscles which he found in the prothorax of the grasshopper *Dissosteira* attached between the apophyses and the first spina. Also according to Speyer (7) in the larva of *Dytiscus* there are muscle fibres from the apophyses to the first abdominal antecosta, but these, Bauer states (1) disappear in the adult.

On the other hand, however, quite a number of insects are known to possess a muscular connection between the metasternum and the second abdominal sternum. Such muscles occur in *Blatta*, and also in *Gryllus* (Voss, 8) in *Cicada* (Snodgrass, 6) and in the nymph but not in the adult of *Psylla mali* Schmdbg. (Weber, 9). They are also found in some Hymenoptera, such as Tenthredinidae (Weber, 9) and in the honeybee (Morison, 5). In all these cases the muscles arise from, or immediately behind, the apophyses, and are inserted on the anterior margin of the second abdominal sternite. Needless to say, in a good many cases the latter is the *first definitive* sternite, owing to reduction in size or sclerotisation in the (morphological) first sternite. It is usually accepted that these are muscles which belong to the first segment and have made secondary attachment with the apophyses, though how this may have been brought about has never been stated explicitly.

It seems to the author that the muscles observed in *Dindymus* likewise probably belong to the first abdominal segment, but although the alimentary canal, sense organs, etc., of the Heteroptera have been extensively studied, the musculature is comparatively little known. The most recent and detailed work is that of Malouf (4). According to this worker, in the metathorax of the Pentatomid *Nezara viridula* (L.) a pair of muscles originate on the apophyses and are inserted on to the anterior margin of the *first* abdominal sternum. Malouf terms them the "posterior sternal longitudinal muscles of the metathorax," and says that they disappear in the adult insect. Although he does not offer an homology, it is clear that if they are as he states, they cannot correspond to the muscles just described in Hymenoptera and Orthoptera, though they might be homologous with the furco-abdominal muscles of EPHEMERIDAE, or with the furco-spinal muscles of the prothorax of *Dissosteira*. Malouf himself was aware of this, for he expressly remarks that as the ventral muscles of the first abdominal segment of *Nezara* have disappeared in consequence of the reduction of the sternum, he took special care to assure himself that the insertion of the muscles he describes was on the first and not on the second abdominal antecosta. If this really is the case, then the Heteroptera must differ from all other insects with a reduced first abdominal sternum, and re-examination of the structure of bugs from this point of view seemed desirable. The nymph of the Pentatomid *Piezodorus lituratus* Fab., whose large size and comparative abundance made it a convenient subject, was compared with Malouf's figures; and this observation showed that his conclusions were based on misinterpretation of the sclerites. In this form the antecostal region of the second abdominal sternum forms a swollen ridge so wide that the longitudinal muscle bands arising from its posterior surface are separated by a considerable space from those inserted in front. It is this space which Malouf thought represented the sternum of the telescoped first abdominal segment; but detailed examination shows that it is in fact the intersegmental element between the metasternum and *first definitive* abdominal sternum, that is to say, the second abdominal antecosta. The pair of muscles concerned extend to its anterior margin from the posterior aspect of the metathoracic apophyses and being large and fleshy, they, with the associated fat tissue, fill up most of the space behind the furcal arms. This of course applies only to the nymph, for, as Malouf points out, in the mature bug these muscles either disappear or are represented only by a pair of slender semi-sclerotised bands. Further investigation showed that in some other Heteroptera the thoraco-abdominal muscles may persist throughout life. For instance, in various CAPSIDAE (*Lygus*, *Notostira*, *Capsus*, etc.) they are constantly present in the adult as well as in the nymph as a pair of large muscles attached to the whole posterior face of the apophyses. Also in some of the water-bugs, such as *Corixa* and *Naucoris*, they occur in all stages; and in correlation with the great development of the hind legs in these forms, they are relatively enormous, and the second abdominal antecosta projects into the visceral cavity as a broad plate. Hamilton (3) describes a very small pair of similar muscles in *Nepa*. I have observed them in *Gerris*, and they can be demonstrated in *Triatoma* (REDUVIIDAE) and in *Salda*. On the other hand, they appear to be absent in all stages of *Nabis*.

Owing to their insertion on the second abdominal antecosta, it may reasonably be assumed that the muscles under discussion belong to the first abdominal segment; but what has been the fate of the related sternum, and how has transference to the apophyses taken place? A study of Capsid structure suggests that so far from the first sternum being obsolete, as Malouf's interpretation supposes, a good deal of it remains to form the posterior coxal bridge.

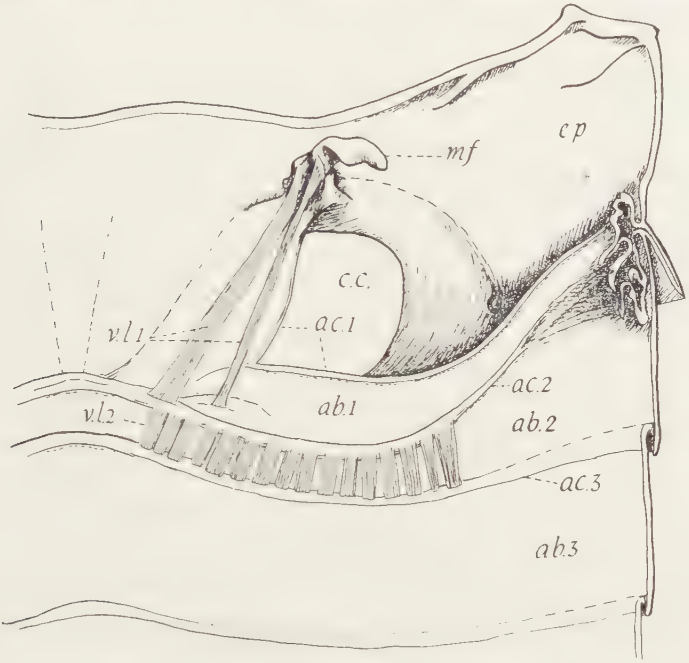


FIG. 1.—Right half of the metathoracic sternum of *Dindymus*, seen from above, to show its relation to the first abdominal sternum and the longitudinal muscles (semidiagrammatic). *ab.* 1–*ab.* 3, sterna of the first three abdominal segments; *ac.*, antecosta; *c.c.*, coxal cavity; *ep.*, episternum; *mf.*, metafurca *v.l.* 1–*v.l.* 2, ventral longitudinal muscles of the first and second abdominal segments respectively.

This involves reduction of the primitive epimero-metasternal connection, which is reduced to a semi-membranous rim round the posterior margin of the coxal cavity. The antecosta of the first abdominal segment, which is of course the sternal extension of the third phragma, can be traced into the raised posterior margin of the coxal cavity at its pleural angle; and again at the mesial angle against the metasternum in some forms a ridge or crest can be seen passing forward along the apophysis. The muscle fibres originate on this crest, and the conclusion therefore is that this thickened margin of the coxal bridge is formed by the first abdominal antecosta; and that in bugs the development of the mesothorax at the expense of the structures behind it, coupled with the need for bracing forward the heavy abdomen, has resulted not so much in the telescoping of the first abdominal sternum as Malouf suggests, as in its superimposition and fusion with that region of the metathorax which lies immediately in front of it. In some forms, such as *Nabis*, in which the postcoxal bridge is wide and well sclerotised, the pleural limits of the first abdominal sternum can be distinguished by the insertion of the tergo-sternal muscle which originates on the first abdominal tergum and is inserted on a strong backward-projecting process from the definitive postcoxal bridge. The condition in the cockroach is interesting, and more specialised than that of the bug. Here there is a heavy abdomen to support, and, in addition, probably owing to the great development of the posterior coxae beneath it, the first abdominal sternum is only feebly sclerotised. Possibly in compensation, the ventral longitudinal muscles are well developed. The most anterior of the series rise along the whole posterior outer aspect of the apophyses; and the latter, in conformity with the adaptive flattening of the body in this form, are reflexed so sharply that the muscles seem actually to be in contact with the metasternal floor.

The metafurcal attachment of the thoraco-abdominal muscles is difficult to explain otherwise than by the replacement of the posterior region of the thorax by the first abdominal sternum. The alternative is to suppose that the muscle fibres have gradually crept forward from their original antecostal situation to a new attachment on the apophyses. Snodgrass (6) suggests this, though doubtless figuratively, when he remarks that in some forms "the anterior ends of the fibres may have migrated to the segmental regions of the definitive terga and sterna"; but on mechanical grounds it is difficult to see how such a shift could have taken place since traction would be exercised in the opposite direction. On the other hand, Morison, discussing this point in the honeybee (5), observes that the "sternum of the propodaeum is too flexible to give support to the large muscles required to help in controlling the movements of the post-abdomen, so these two pairs of muscles originate from the third furca of the thorax *unless it can be shown that the chitin to which they are attached on the third furca really belongs to the sternum of the propodaeum*" (italics mine). The suggestion made here is that in bugs the plate from which the sternal muscles rise in the metathorax can be fairly homologised with part of the antecosta of the first abdominal segment which in virtue of its function retained its identity when the body of the sternum became reduced. Any exoskeletal area to which muscles are attached must for mechanical reasons remain relatively well sclerotised and permanent no matter how much degeneration takes place in the surrounding plates. Thus Morison is justified in holding that the sclerite to which the muscles are attached is literally a part of the first abdominal segment which has been thrust into its present position on the furcal arms by the consolidation of the pterothorax and anterior part of the abdomen. That this has happened not only in the bug and the honeybee, but in other insects also, hardly admits a doubt.

References.

1. Bauer, A., 1910, Die Musculatur von *Dystiscus marginalis*. *Z. wiss. Zool.*, **95** : 594.
2. Dürcken, B., 1907, Die Tracheenkiemenmusculatur der Ephemeriden unter Berucksichtigung der Morphologie des Insektenflügels. *Z. wiss. Zool.*, **87** : 435.
3. Hamilton, Marion A., 1931, The Morphology of the Water-scorpion, *Nepa cinerea*. *Proc. zool. Soc. Lond.*, **3** : 1068.
4. Malouf, N. S. R., 1932, The Skeletal Motor Mechanism of the Thorax of the Stink-bug, *Nezara viridula*. *Bull. Soc. ent. Égypte*, **16** : 161.
5. Morison, G. D., 1927, The Muscles of the adult Honeybee (*Apis mellifera*). *Quart. J. micr. Sci.*, **71** : 395.
6. Snodgrass, R. E., 1929, The Thoracic Mechanism of a Grasshopper and its antecedents. *Smithson. misc. Coll.*, **82** : 1.
7. Speyer, W., 1922, Die Musculatur der Larve von *Dystiscus marginalis*. *Z. wiss. Zool.*, **119** : 423.
8. Voss, H., 1925, Ueber den Thorax von *Gryllus domesticus*. *Z. wiss. Zool.*, **78** : 268.
9. Weber, H., 1929, Kopf und Thorax von *Psylla mali*. *Z. Morph. Ökol. Tiere*, **14** : 59.

STUDIES ON THE DISTRIBUTION OF NITROGEN IN INSECTS. II. A NOTE ON THE ESTIMATION AND SOME PROPERTIES OF INSECT CUTICLE

By A. C. Evans, F.R.E.S.

(*Rothamsted Experimental Station.*)

Buxton (1932) described a method for the estimation of insect cuticle by hydrolysing ground-dried insects in 1% KOH for 4 hours and weighing the remains which were taken to be cuticle. Buxton refers to the cuticle as skeleton, but most writers on this subject refer to it as cuticle, since its functions are very different from those of vertebrate skeleton. Evans (1938) used this method to determine the amount of cuticle in the various castes of the wasp *Vespula germanica* (Fab.) and found certain anomalous results which suggested that a portion of the cuticle is soluble in 1% KOH. A critical examination showed that about 60% by weight of the cuticle and 65–70% of the total N present was lost by this method (Table I). Just-emerged queens are those which have emerged from the pupa within 2–3 hours and have poorly developed fat-bodies; hibernating queens have their fat-bodies well developed in preparation for hibernation and their cuticle is much harder than that of just-emerged queens.

Table I.

The effect of 1% KOH on the abdominal cuticle of the wasp.

%	Hibernating queens		Just-emerged queens	
Loss in weight	57·6	58·9	60·4	60·0
N lost	67·3	66·5	68·5	69·1
Total N	12·2	12·3	13·4	13·3
N in extracted material	14·2	13·9	15·2	15·3
N in residues	9·4	10·0	10·6	10·3

In view of these results it was thought worth while to study the problem further, especially as a knowledge of the amount and composition of the cuticle should prove of interest in the study of the comparative chemistry of insects and in the mode of action of contact insecticides.

Experimental.

The larva of the mealworm, *Tenebrio molitor* L., was used as a subject. A small amount of clean cuticle was prepared by scraping the abdomens of several larvae with a blunt scalpel and cleaning off any small pieces of adhering tissue with cotton-wool swabs. It was found that about 60% of this material dissolved when heated in 1% KOH, 1% H_2SO_4 or dilute citric acid on a boiling water-bath for 4 hours. A more convenient method of preparing cuticle was sought. It was found that if mealworms were killed with ether and the tissues allowed to autolyse until the thorax began to blacken, a material showing the same properties as scraped cuticle could be prepared in the following manner. Autolysed larvae were cut open laterally, pinned down, and the tissues washed away with a strong fine jet of water. Any small pieces of tissue remaining were cleaned off with cotton-wool swabs under a binocular microscope. The weights of cuticle obtained from duplicate sets of

10 abdomens by scraping and autolysis were 49·6 mg., 45·0 mg. and 45·0 mg., 44·5 mg. respectively; the % N contents were 12·9, 12·7 and 13·2, 13·6 respectively. The results reported below were obtained on material prepared by the autolytic method. The % cuticle, on a dry weight basis, present in normal larvae weighing about 110–130 mg. was 15·3% and 14·8%; in just-moulted larvae which had not begun to assume the normal brown colour it was 12·8% and 11·9%. The N content of the cuticle of just moulted larvae was 13·9% and 13·6%, the same as for normal larvae. This result supports the view expressed by Campbell (1929) for the cockroach, that chitin and admixtures are formed concurrently in the cuticle and are laid down in intimate association in about the same proportions in which they are subsequently found in hardened cuticle. This view, however, does not seem to be true in the case of the adult wasp, since the abdominal cuticle of the just-emerged queen has a higher % N than that of the hibernating queens (Table I). The abdominal cuticle of the hibernating queen is about 12% heavier than that of the just-emerged queen, so it seems that after emergence a substance or mixture of substances with a N content lower than that of the young cuticle is laid down.

Buxton (1932) reported the % cuticle of mealworm larvae to be 8·2–8·3% on a dry weight basis. The big discrepancy between these figures and the ones reported above is clearly due, in part, to solution of cuticular material in 1% KOH. Since more than 60% is removed an even bigger difference was expected. It seems likely that this bigger difference was not found because mealworms contain substances insoluble in 1% KOH other than a part of the cuticle. If some of the autolysed tissues are heated in 1% KOH it is found that besides tracheae a white granular substance remains insoluble.

Table II.

Relation between % loss of weight of cuticle in 1% KOH and time.

Time in hr.	¼	½	1	2
% Loss in wt.	59·9	62·1	64·7	65·9

Table II shows that about 60% of the cuticle is extracted after ¼ hour on a boiling water-bath and still more on prolonged heating. The sudden change in the rate of loss of weight after ¼ hour suggests that at least two substances are removed, one very soluble and the other only slowly broken down. The N contents of the substances going into solution after 1 hour's and 2 hours' extraction are 15·6% and 15·4% and those of the residue 9·2% and 8·5% respectively. The data are not extensive enough to show whether the differences are significant. The cuticle of a blowfly larva *Calliphora erythrocephala* Mg. was also examined; the N content of the KOH soluble part was 15·6% and that of the residues 7·1%. The N content of the residues of the blowfly larval cuticle is definitely lower than that of *Tenebrio* residues, while the N content of the soluble substances is the same. In the case of the blowfly only 51% of the cleaned cuticle was lost on heating for 2 hours in 1% KOH. The N content of the extracted material suggests that it is chiefly of a protein nature, and that the cuticle contains a great deal of protein is shown by the strong positive xanthoproteic and Millon reactions and weak biuret reaction given by aqueous or dilute alkaline extract of ground cuticle.

Wigglesworth (1933) showed that the blood-sucking bug *Rhodnius prolixus* Stål absorbs a great deal of its cuticle before moulting. Some idea of the amount of cuticle absorbed by mealworm larvae on moulting can be obtained by comparing the weight of the cuticle before moulting with that of the exuviae. Larvae weighing 110–130 mg. contain 7·8–8·2 mg. of skeleton, while the exuviae weigh 1·3–1·4 mg., thus about 83–85% of the cuticle is absorbed. About 80% of the cuticle is absorbed by larvae preparing to pupate. The results agree very closely with those found by Wigglesworth for the abdominal cuticle of *Rhodnius*. The N content of the exuviae is 11·8%, rather less than that of the complete cuticle; 50–51% by weight is lost on heating for 2 hours in 1% KOH. The exuviae do not correspond at all to that fraction of the cuticle left after extraction on 1% KOH. The weight of residue per larval cuticle after extraction is about 3·4 mg., much higher than that of the exuviae, while its N content is lower, 8·5–9·2% compared with 11·8%

The very labile nature of a great part of insect cuticle suggests that it will be difficult to find a simple and rapid chemical method for its estimation. For work within a single stage of the life-history of one insect an empirical method might prove of use. The insect could be cut into several small pieces, hydrolysed in 1% KOH for a given time and the residues thoroughly washed, dried and weighed, the loss in weight of clean cuticle under the given conditions of hydrolysis being previously determined and this factor used to calculate the true value. If it is not possible to estimate the amount of cuticle in the insect at once, preservation in 60% alcohol for a few days may permit of useful results being obtained by the scraping method. Cuticle was allowed to stand in 60% alcohol for two weeks and at the end of that time had lost only 3% of its weight.

Table III shows that the percentage cuticle increases from the last but one to the last instar, decreases considerably in the pupa and increases to a maximum in the young starved adult, although the latter contains slightly less cuticle than the full-grown larva. A considerable economy in the synthesis of cuticular material would seem to be effected by the absorption of over 80% of the old cuticle, thus about 55% of the cuticle of the last instar larva is formed of material absorbed from the cuticle of the previous

TABLE III.

Changes in amount and character of cuticle during the later phases of the life history, on a basis of one individual. *Tenebrio molitor* L.

	Last but one instar. Larvae of about 120 mg.	Last instar. Larvae of about 160 mg.	Pupa. 1–2 days	Adult. 1–2 days
Wt. of cuticle (mg.)	8·0	11·7	5·7	10·6
Wt. of exuviae (mg.)	1·4	1·7	1·1	—
Amount absorbed at moulting (mg.)	6·6	10·0	4·6	—
% cuticle (wet wt. basis)	6·4	7·3	4·9	11·9
% loss in wt. on 1% KOH hydrolysis for 2 hr.	66	68	72	53
% total N in cuticle	12·8	13·0	13·6	12·0
% N of KOH soluble substances	15·5	15·0	15·4	14·0
% N of residues	8·9	8·7	8·8	10·8
Total N in cuticle (mg.)	1·02	1·52	0·78	1·27
Total N in exuviae (mg.)	0·17	0·21	0·14	—
Amount absorbed at moulting (mg.)	0·85	1·31	0·64	—

instar. In the case of the pupa the total amount of the cuticle present is very much less than that absorbed from the cuticle of the last instar larva, and since the adult beetle contains nearly twice as much cuticle as the pupa it would seem feasible to suppose that the excess larval cuticular material is stored through the pupal stage and used to build up part of the adult cuticle. Since 2·8 mg. of cuticular material is lost in the last larval and pupal instar, 8·9 mg. of the last instar larval cuticle should be available to help to form the 10·6 mg. of adult cuticle. Similarly it can be shown that 1·17 mg. N from the last larval instar may contribute to the 1·27 mg. N found in the adult cuticle. In the wasp *Vespula germanica* the larval cuticle cannot contribute any appreciable amount of N to the adult cuticle, since it contains only between 1–2% of the amount present in the adult cuticle.

The % loss in weight of the cuticle in 1% KOH after hydrolysis on a boiling water-bath for 2 hours is the same in both the larval instars studied; in the pupa it is slightly more than in the larva, but in the adult very much less than in either pupa or larva. The % total N in the cuticle is less in the adult than in larva or pupa: a significant difference was not found in N contents of the larval and pupal cuticle. The N content of the material soluble in 1% KOH and of the insoluble residue is the same in larva and pupa, but in the case of the adult the soluble material has a lower N content and the residues a higher N content.

SUMMARY.

It is shown that the cuticle of the mealworm *Tenebrio molitor* L. contains about 60% protein, which is easily soluble in water, dilute acids and alkalis. The hypothesis is put forward that, in this insect, the material absorbed from the cuticle at the last moult may eventually be utilised to form the major part of the adult cuticle.

REFERENCES.

BUXTON, P. A., 1932, *Biochem. J.*, **26** : 829.
CAMPBELL, F. L., 1929, *Ann. ent. Soc. Amer.*, **22** : 401.
EVANS, A. C., 1938, *Proc. R. ent. Soc. Lond.* (A), **13** : 25.
WIGGLESWORTH, V. B., 1933, *Quart. J. micr. Sci.*, **76** : 270.

BOOK NOTICE.

Nature Study above and below the surface. A bridge between amateur and professional. By H. C. GUNTON, with preface by Dr. C. B. WILLIAMS. London (H. F. and G. Witherby, Ltd.). 1938. pp. 134, 18 figs. Price 7*s.* 6*d.*

This book is divided into four sections as follows: I, Introduction, pp. 13–52; II, Outstanding phenomena, pp. 53–120; III, Applied entomology, pp. 121–133; and IV, The Bridge, pp. 133–134.

In the first section details of insects likely to be observed by an amateur are given and when and where they may be observed throughout the year, and cognate data such as the date of appearance of certain blossom and the breaking into leaf of certain trees or shrubs.

The second section is devoted to an exploration of such phenomena as mimicry, hibernation, migration and activity of nocturnal insects.

The third section lists applications of the principle of biological control and other methods of applied entomology.

BRUNNER'S ORGAN; A STRUCTURE FOUND ON THE JUMPING LEGS OF GRASSHOPPERS (ORTHOPTERA)

By Eleanor H. Slifer
(*Department of Zoology, State University of Iowa.*)
and
B. P. Uvarov, D.Sc., F.R.E.S.
(*British Museum* (*Natural History*).)

With Plate 1.

It is nearly sixty years ago that Brunner von Wattenwyl (1880) published a note on a curious small structure, " ein stumpfes Dorn," on the underside of the femur of the jumping legs of grasshoppers, which he found in all the European Acrididae examined by him.

" In der Hohlkehle auf der Unterseite des Hinterschenkels, [he states] in welche sich bei der Vorbereitung zum Sprunge die Schiene anschmiegt, findet man nahe dem Rande, etwa im vierten Theile der Länge von der Basis angerechnet, eine warzenförmige Erhöhung, welche unter der Lupe betrachtet, sich als eine runde Oeffnung in der Chitinmasse erweist, in welcher ein weicher Polster sich findet, der sich mitunter zu einer stumpfen Tuberkel hervordrängt. Der etwas aufgeworfene Rand ist auf der Basalseite mit einzelnen zarten, weissen Haaren besetzt und der Polster, welcher den Eindruck einer Drüse macht, ist stets weisslich oder grau gefärbt." According to Brunner the occurrence of the structure cannot be correlated with sound-production, for it is present on the femora of both sound-producing and of silent species. On the other hand, it is lacking in those forms (" Proscopiden und Pneumoriden ") which have not the hind legs modified for jumping. Krauss, as Brunner notes, had pictured the tubercle in his 1878 paper on *Cucculligera hystrix* Germ., but had considered it to be nothing more than an irregularity of the surface of the femur.

Since Brunner gave the first description of this structure, we propose that the tubercle, together with the associated sensillae, be known as Brunner's organ.

Structure.

The structure of the organ was studied by E. H. Slifer in *Melanoplus differentialis* Uhl. All of the nymphal instars, freshly-moulted adults and adults with a completely hardened exoskeleton were examined. Either the entire femur was fixed or else that portion of its surface which contained Brunner's organ was cut out and fixed separately. Carnoy-Lebrun's, Bouin's, Champy's and Schwabe's fluids were used for fixation and Heidenhain's iron-hematoxylin, Galigher's alum-hematoxylin, Mallory's connective tissue stain, fast green, triosin and picronigrosin were used for staining. Some preparations were stained vitally with methylene blue and treated with Cole's fixative.

It is not easy to obtain good serial sections of the heavy-walled adult femur but it was found, finally, that these could be secured by keeping the microtome knife extremely sharp and by moistening the face of the block with damp paper immediately before cutting each section. After removal of the paraffin from the slides, in preparation for staining, the slides were placed for a few moments in absolute alcohol, then in a dilute solution of celloidin in alcohol and ether before being transferred to 70% alcohol. The thin coat of celloidin prevented the cuticle from loosening, as it is apt to do during the long exposure to watery staining solutions.

Whole mounts of the entire organ, of pieces of exuviae which contained it, and preparations which had been boiled in KOH, were also made. In addition, the major nerves of the leg and the nerve which leads from these to the base of the tubercle were studied in dissected material.

Brunner's organ is located, in *Melanoplus differentialis*, on the innermost of the two ridges which run along the under surface of the metathoracic femur (fig. 1, A, TU). The tubercle is approximately 0·15 mm. high and 0·12 mm. wide, but the size varies considerably from individual to individual. Its free end is curved distally. In the living condition the tubercle is so soft and delicate in texture that it reminds one of a fluid-filled blister. The lightest touch is sufficient to press it out of shape. In dried specimens the tubercle is hard, shrunken and much less conspicuous. Just proximal to the base of the tubercle and curving over it are four or five long tactile hairs and proximal to these hairs are several minute depressions which represent the outer ends of campaniform sensillae (fig. 1, B). Brunner's organ is well developed in grasshoppers which have just hatched and persists through adult life. No differences between those taken from male and those from female animals could be detected.

The structures described above are innervated by a nerve which leaves the innermost of the three larger femoral nerves (fig. 2, N), passes between the ventrally-located depressor muscles of the tibia (fig. 2, DT) and then swings down gradually towards the lower surface of the femur. The nerve branches repeatedly on the inner surface of the epidermis just below the tubercle. A loose mass of fatty tissue binds the branches together and from this network small nerves pass to the trichoid and campaniform sensillae.

In sectioned material from an animal which has just completed its final moult the cuticle of the tubercle is still relatively thin, for in the grasshopper the greater part of the cuticle of the body wall is deposited after ecdysis has occurred. At this time the centre of the tubercle is occupied by a bundle of long, slender epidermal cells (fig. 3). The sensory and other cells associated with the trichoid and campaniform sensillae can be identified but are much less conspicuous than they will be later.

Material from older animals in which the secretion of the cuticle has been completed is decidedly more satisfactory for study. Here the entire centre of the tubercle is found to be filled with a cuticular deposit which has been formed by the elongate epidermal cells. These cells have become much shorter and now form a layer which is little thicker than that found elsewhere on the surface of the leg (fig. 6).

The trichoid sensillae are composed of the elements usually found in such structures. A trichogenous cell which contains a large vacuole lies just below the slender, curved hair and the distal tip of a sensory cell extends up through the vacuole to the base of the hair (fig. 5). The sensory cell is enclosed in a portion of the neurilemma, which here enters the epidermal layer, and its proximal end is continuous with a nerve which emerges from the network which lies just below the epidermis.

The sensory cells of the campaniform sensillae also receive branches from the sub-epidermal plexus and the distal tip of each is attached to the under surface of the bell-shaped outer end of the sensilla (fig. 4).

In addition to the more typical epidermal cells a number of large glandular cells which are filled with brown, vacuolate material and each of which contains a secretory vesicle and a ductule were found scattered here and there in the basal portion of the epidermis (fig. 7). These occur both below the tubercle and in other locations. The ductules which lead from the secretory vesicles pass to the base of the cuticle but could not be followed farther. Whether they open there or whether—as is more likely—they lead to the surface of the cuticle was not determined. They are extremely narrow, tend to curve and, in consequence, are very difficult to trace from section to section. Cells of this type are not uncommon in the epidermis of insects. Schulze (1934), for example, described them in the epidermis of various species of Odonata. He was able to follow the ductule to the outer surface of the cuticle and, with the use of Sudan III, came to the conclusion that the glands secrete a fat-like material which spreads over the surface of the body and acts as a lubricant. In Schulze's words the glands are "Schmierdrüsen, deren Sekret die Aufgabe hat, das Chitin geschmeidig zu erhalten."

Possible Function.

In order to learn, if possible, something concerning the function of Brunner's organ the structures were destroyed, with a hot needle, on both femora of fourteen adult males and of a similar number of adult females. No anaesthetic was used, for it was found, in preliminary experiments, that ether or chloroform may affect the reactions of the animals for a considerable time afterwards. The individuals from which the tubercles had been removed behaved, so far as could be observed, exactly as do normal animals. They jumped, walked and fed as if nothing had happened. In fact, some began feeding a few minutes after the tubercles had been cauterised. Copulation occurred as in the controls and the females laid eggs in the usual manner. These results are not particularly surprising, since individuals from which both metathoracic legs have been entirely removed are also able to carry out these activities with, of course, the exception of jumping.

Pringle (1938) has recently shown that campaniform sensillae on the legs of *Periplaneta* respond to strains in the cuticle. This may apply to campaniform sensillae at the base of Brunner's organ in Acrididae, but the position and the structure of the organ as a whole suggest that its function is not restricted to the perception of cuticular strain.

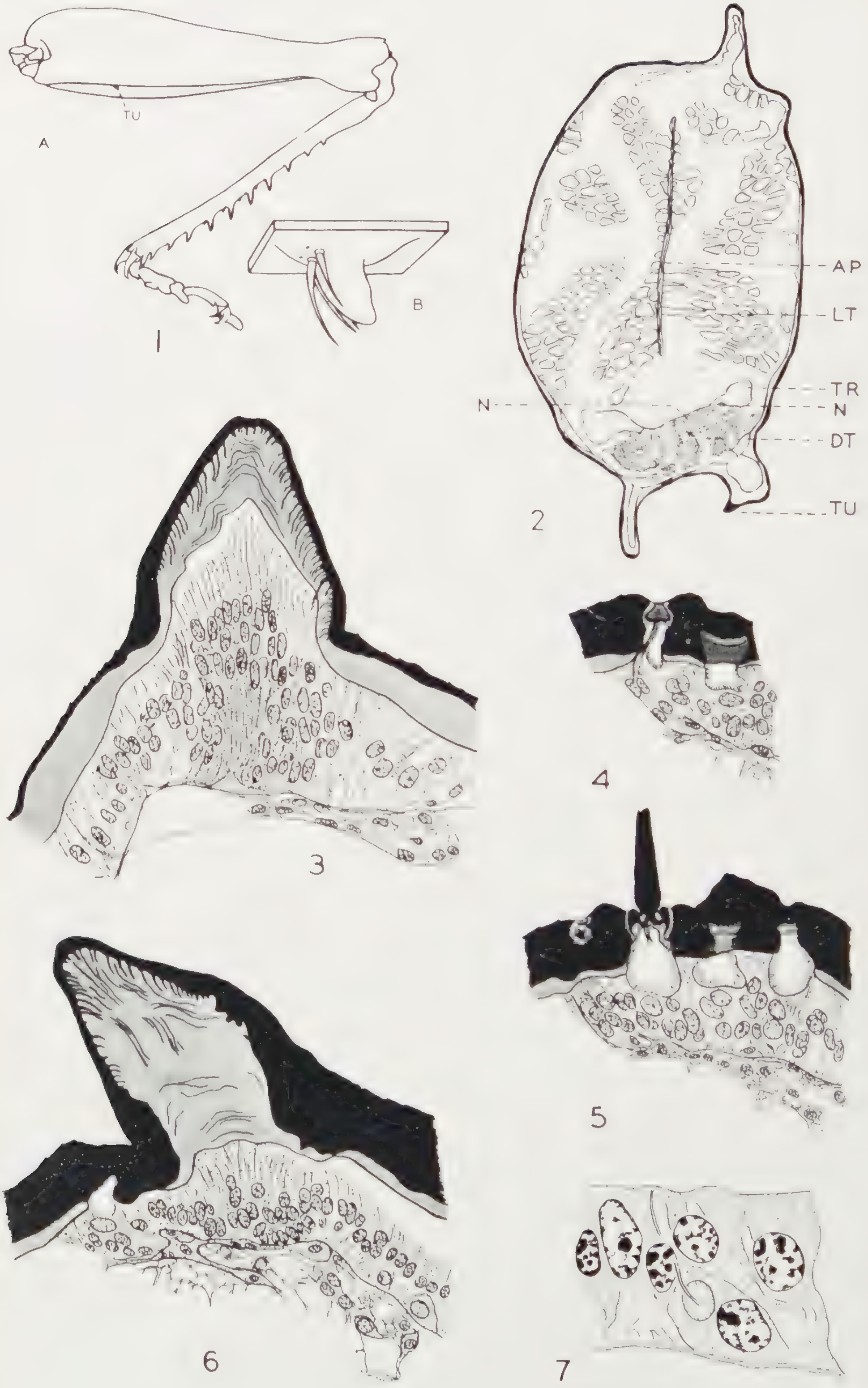
If the metathoracic tibia of a living grasshopper is flexed against the femur, Brunner's tubercle will be seen to flatten as the tibia touches it. Again, the organ may be prodded gently with a blunt needle without eliciting any response which might be interpreted as one of irritation on the part of the animal. Another clue to the function of Brunner's organ may be found in the well-known fact that resting grasshoppers keep their metathoracic tibiae pressed firmly against their femora. Taken together, these observations lead one to the conclusion that Brunner's organ is involved in a positive contact reflex which tends to keep the tibia in contact with the femur so long as stimuli which tend to inhibit or to override this reflex are absent. One serious objection to this conclusion may be raised. Grasshoppers from which the tubercles have been removed still rest with their tibiae pressed firmly against their femora. A possible answer to this might be that adult grasshoppers have, by long usage, so firmly acquired the habit of keeping the tibiae and femora in contact that the disappearance of the tubercle does not result in the disappearance of the habit. It would be interesting to remove the tubercles from first instar grasshoppers and to note whether, as the animals develop, the habit of keeping the femora and tibiae in contact is so firmly ingrained as it is in normal animals.

OCCURRENCE IN ACRIDIDAE AND OTHER GROUPS.

As already stated by Brunner, this organ was present in all European ACRIDIDAE which he examined, and this conclusion has been verified (by B. P. Uvarov) by examination of over one hundred genera from all over the world (in addition to some thirty North American genera studied by E. H. Slifer), belonging to the subfamilies EUMASTACINAE, ACRIDINAE, OEDIPODINAE, BATRACHOTETRIGINAE, PAMPHAGINAE, OMMEXECHINAE, PAULINIINAE, PYRGOMORPHINAE and CATANTOPINAE. Special attention was paid to the selection of genera both of typical habitus and highly aberrant ones, as well as to the examination of representatives of genera most widely different ecologically. No apparent correlation was found even in the degree of development of the organ with the taxonomic position of the insects, nor with their ecology. In view of the possible connection of Brunner's organ with the act of jumping, representatives of genera with powerful jumping legs were compared with numerous others in which the metathoracic femora are scarcely incrassate and which are known to be very poor jumpers, such as *Gomphomastax*, *Acrida*, *Phymateus*, *Lentula*, etc. However, Brunner's organ proved to be well developed in all of them. Only in a few genera of CATANTOPINAE such as *Oxyrrhepes*, *Leptacris*, *Rhamphacrida*, *Acanthoxia* and *Betiscа*, the organ was found to be very small in size, often scarcely visible without a binocular microscope. These are insects with extremely elongate body and very narrow posterior femora, living on tall savanna grasses. The usual resting position of these insects is vertical, clinging to a stem of grass, with the metathoracic tibiae tightly pressed against the femora. It is doubtful whether they can jump at all and, in any case, they do so on very rare occasions. It would appear, therefore, that Brunner's organ may undergo some secondary reduction in the species that have lost the habit of jumping. On the other hand, a well-developed organ is found in insects like *Mecostibus* and *Hemiacris*, which live closely clinging to branches of tropical trees and probably also never jump. This suggests that the reduction of Brunner's organ is probably a very slow process.

Of distinct taxonomic interest is the fact, already observed by Brunner, that the organ is absent in PNEUMORIDAE and PROSCOPHIDAE. He regarded these groups as merely subdivisions of ACRIDIDAE and suggested that the absence of the organ in them is associated with their inability to jump. Since the organ is present in all true ACRIDIDAE, regardless of their jumping powers, its complete absence in PROSCOPHIDAE and PNEUMORIDAE cannot be explained as a secondary reduction, but must be regarded as a primary character of definite phylogenetic significance. Taken in conjunction with various other characters, it lends strong support to the view that the PROSCOPHIDAE and PNEUMORIDAE should be regarded as groups equal in rank to true ACRIDIDAE, *i.e.*, as independent families.

Another interesting point of family systematics is raised by the presence of well-developed Brunner's organ in TETRIGIDAE, which differ profoundly from ACRIDIDAE in many morphological, anatomical, cytological, etc., features and are justly regarded as a distinct family. With regard to Brunner's organ, they appear to be more closely related to ACRIDIDAE than to any other family, but it would be obviously unreasonable to attach too great a taxonomic value to this character alone.



ENGRAVED BY STAR ILLUSTRATION, LONDON.

A structure on the jumping legs of grasshoppers.

No trace of Brunner's organ was found in representatives of other Orthopteroid groups with jumping metathoracic legs, *i.e.*, in GRYLLIDAE, GRYLLACRIDIDAE, TETTIGONIIDAE and TRIDACTYLIDAE. Its absence in the last-named family is of special interest, since in many other characters it is close to the ACRIDIDAE.

It was thought that other insects with legs modified for jumping might possess structures similar to Brunner's organ, but nothing resembling it was found in a jumping beetle (*Disonychia triangularis*) and in a flea (*Ctenocephalus felis*).

REFERENCES.

BRUNNER V. WATTENWYL, C., 1880, Neues Organ bei Acridiern. *Verh. zool. bot. Ges. Wien*, **29** : 26–27.

KRAUSS, H., 1878, Die Orthopteren-Fauna Istriens. *SitzBer. Akad. Wiss. Wien*, **78** : 451–544.

PRINGLE, J. W., 1938, Proprioception in insects. ii. The action of the campaniform sensilla on the legs. *J. exp. Biol.* **15** : 114–131.

SCHULZE, K., 1934, Die Hautdrüsen der Odonaten : Bau, Verteilung, Entwicklung und Funktion. *Zool. Jahrb.* (*Anat.*), **58** : 239–274.

EXPLANATION OF PLATE 1.

FIG. 1.—A, Right metathoracic leg of *Melanoplus differentialis* as seen from inner surface. TU, tubercle of Brunner's organ, × 10. B, Brunner's organ. Note tactile hairs which arch over the tubercle. Two of the four campaniform sensillae which are present may be seen to the left of the bases of the hairs. × *c.* 130.

FIG. 2.—Cross section through metathoracic femur of *Melanoplus differentialis.* AP, apodeme; DT, depressor muscles of the tibia; LT, levator muscles of the tibia; N, nerve; TR, trachea; TU, tubercle of Brunner's organ. The nerve farthest to the right innervates Brunner's organ. × *c.* 17.

FIG. 3.—Section through tubercle of Brunner's organ from *Melanoplus differentialis* killed while undergoing the final moult. Note slender epidermal cells which fill the centre of the tubercle. Compare height of cuticle with that in figure 6. Carnoy-Lebrun, Heidenhain's iron-hematoxylin. × *c.* 270.

FIG. 4.—Section through outer end of campaniform sensilla of Brunner's organ from animal with well-hardened cuticle. Sensory cell in an adjacent section. Bouin, Heidenhain's iron-hematoxylin. × *c.* 270.

FIG. 5.—Section through tactile sensillae from Brunner's organ. Note vacuole at base of hair. Bouin, Heidenhain's iron-hematoxylin. × *c.* 270.

FIG. 6.—Section through tubercle of Brunner's organ from animal with well-hardened cuticle. Note that centre of tubercle is filled with a cuticular deposit and that the epidermal cells are lower than in figure 3. The vacuole of a tactile sensilla may be seen to the left of the base of the tubercle and a gland cell in the epidermis in the lower right-hand corner. Note network of nerves and fatty tissue below the epidermis. Bouin, Heidenhain's iron-hematoxylin. × *c.* 270.

FIG. 7.—Section through portion of epidermis containing a gland cell. Note secreting vesicle and ductule. A basement membrane lies below the epidermis. The cuticle has been omitted. Bouin, Heidenhain's iron-hematoxylin. × *c.* 1200.

BOOK NOTICE.

A monograph of the British aberrations of the Chalk-hill Blue Butterfly Lysandra coridon (*Poda*, 1761). By P. M. BRIGHT and H. A. LEEDS. 4to. Bournemouth, 1938 (The Richmond Hill Printing Works, Ltd.). pp. x + 138 + [iv] 18 pls. (col.).

This book, as its title suggests, is a monograph of a British Butterfly with especial regard to the aberrations known to occur in the species.

The work is divided into chapters as follows :—

Life history and range.
Male and female scaling by F. N. Pierce.
Homoeosis by E. A. Cockayne.
Gynandromorphs by E. A. Cockayne.
Abbreviations and their use.
Introduction to the aberrational forms and their nomenclature.
Description of *L. coridon* type and aberrational forms.
Suggestions for the arrangement of specimens under the aberrational terms.
Explanation of prefixes, affixes, etc.
Tabulations of previous terms used by other authors and employed in this book.
Standardisation of aberrational terms for other species.
Indices.

After long and detailed study of very extensive collections made over a long period of years, the authors have attempted to produce a system of classification of aberrations found in the " Blues " of this country, and this system with its nomenclature is here explained. The suggestion is made that aberrational terms for other butterflies might be standardised and suitable terms are proposed. Several hundreds of illustrations are given on the 18 plates, of which many are in colour. The majority of the specimens studied are from the collection of Mr. P. M. Bright.

BOOK NOTICE.

A Pocket-book of British Butterflies, Moths and other winged insects. By C. A. HALL. pp. 140, 24 pls. col., 16 pls. sm. 8vo. London, 1938 : A. and C. Black. Price 5*s*.

This book aims to " provide lovers of the countryside with illustrations of some of the insects which they may encounter on their travels in Great Britain, and also with some notes about the species figured."

Common English names are used almost exclusively, and, in addition to Lepidoptera, the book gives some information on caddisflies, mayflies, dragonflies, humble bees and social wasps, together with illustrations. The book is addressed to the beginner.

THE INTERNAL ANATOMY OF THE LARVAE OF *PANORPA* AND *BOREUS* (MECOPTERA)

By Edith Potter, Ph.D., F.R.E.S.

Introduction.

The external anatomy and biology of the larvae of some of the families of the order Mecoptera have been described by various authors. Species of *Panorpa* have been described by Brauer * 1863, MacLachlan 1868, Felt * 1894, Miyake * 1912, Shiperovitsh * 1925, Stitz 1926, Esben Petersen 1929, Steiner * 1930, Carpenter 1931, Syms 1933 and Walde 1934.*

The structure and biology of *Boreus hyemalis* larvae were first described by Brauer * 1863 and later by Withycombe * 1921, Esben Petersen 1929, Carpenter 1931 and Syms * 1933.

The larva of *Bittacus tipularius* Latr. (*italicus* Mull.) has been described by Brauer * 1863 and his work reviewed by Carpenter 1931; *Bittacus stigmaterus* Say was studied by Setty * 1931.

Currie * 1932 described the larva of *Harpobittacus tillyardi* E.P.

The authors which are marked by an asterisk in the above list are those who have made new contributions to the subject; the remaining authors have either translated the work of earlier authors or have surveyed or repeated the previous work.

The internal anatomy of the larvae has not so far been studied and the present paper describes the mouthparts and internal anatomy of the larvae of *Panorpa communis* L., *Panorpa germanica* L. and *Boreus hyemalis* L. The larvae of *P. communis* L. and *P. germanica* L. were mixed, but as no internal differences between the larvae were discoverable in numerous dissections, it was assumed that the larvae of these two species were similar internally.

I wish to thank Mr. Hugh Main for his kind assistance in obtaining the larvae of *Boreus hyemalis* L., and Professor J. W. Munro, in whose Department the work was carried out.

Methods.

The *Panorpa* larvae were obtained by breeding, because it is very difficult to find these larvae in the field. Male and female adults were placed in a large cage, the sides, top and front of which were of muslin. A jar containing fresh grasses and leaves was put in it, since scorpion flies are generally found resting on leaves in the shade. Pots of well-drained sand and earth were placed in the cages, and the whole was kept very damp. The adults were fed on small lumps of lean meat, which was renewed every second day.

Several batches of eggs were laid and the resulting larvae were reared in the flower-pots which stood in dishes of water and which were kept covered with muslin covers. The larvae were given the same diet as the adults—small pieces of fresh raw meat, which were changed at frequent intervals. The natural food of the larva is not known. Brauer 1863, Steiner 1930, say that it is omnivorous and that it can be reared on an entirely vegetable diet.

* A paper was published, too late for inclusion here, describing the alimentary canal and salivary glands of *P. communis* L. larva in great detail. Grell, K. G., 1938, Der Darmtraktus von *Panorpa communis* L. und seine Anhänge bei Larve und Imago. *Zool. Jahrb.* (*Abt. Anat.*) **64** : 1–86. 60 figs.

However, in adverse circumstances, the larger larvae frequently eat the smaller and it is probable that the food consists chiefly of animal matter. The mouthparts are more like those of a carnivorous insect than those of a vegetarian, which supports the belief that the larvae are mainly carnivorous.

Towards the end of the summer the larvae became sluggish and burrowed a considerable depth into the earth to hibernate.

The dissections were performed on the full-grown larvae.

The larvae of *Boreus hyemalis* L. were collected in Epping Forest at various times of the year among the roots of the moss *Mnium Hornum* at the base of beech trees. They were kept alive in the moss, in the laboratory, until they were needed. The larvae were killed with ethyl acetate and pinned to the wax of a small dissecting dish. The body was opened, the organs separated from one another and the fat-body removed, in Ringer's solution. This dissecting-fluid was then replaced by 70 per cent. alcohol, which hardened the muscles, rendered the salivary glands opaque and whitened the nervous system.

Panorpa communis L. and *P. germanica* L.

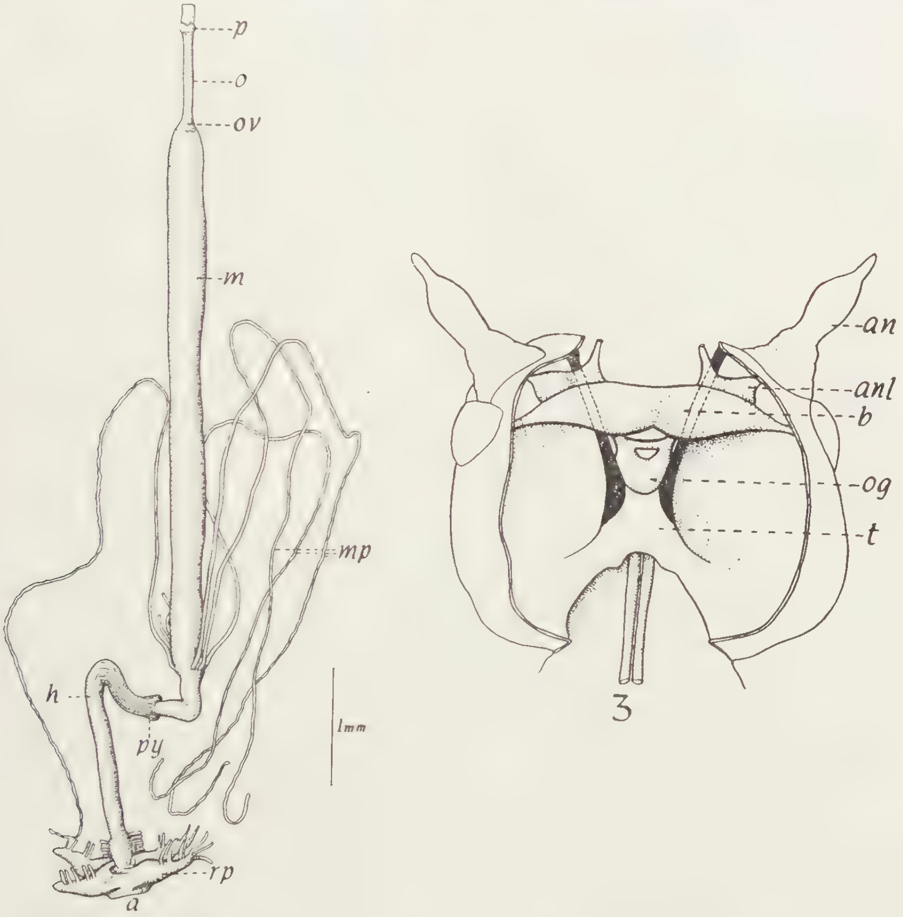
The *mouthparts* of the larva of *P. communis* have been described in detail by Steiner (1930). My observations confirm his description, except with regard to the hypopharynx. There is no true hypopharynx. The ventral wall of the pharynx is prolonged as the lining of the inner or dorsal surface of the labium. Below the labial palps it is thrown into a horizontal fold, which carries hairs along its ridge. Steiner describes this fold as an independent hypopharynx. The salivary duct opens above a small crescent-shaped sclerite on the ventral surface of the labium between the bases of the palpigers.

THE ALIMENTARY CANAL (fig. 1).

The alimentary canal and salivary glands are swathed in a layer of fat-body which is in the form of flat reticulate ribbons. The canal lies in the mid line and is held in position and aerated by numerous tracheae. The dorsal surface of the pharynx is prolonged to form the epipharynx. Just posterior to the mouth, the dorsal wall of the pharynx is cuticularised. This cuticularisation takes the form of a concave plate, the concavity of which intrudes into the lumen of the pharynx. The dorsal anterior surface of the plate carries muscles, but the posterior part stands up like a wing on the dorsal surface of the pharynx, and is deeply notched. The ventral surface of the pharynx is stiffened by a narrow hoop-like strut, which carries short cross pieces on its free ends. The dorsal concave plate functions as a closing apparatus for the pharynx, since when the muscles of the plate relax the lumen is decreased and when they contract it increases.

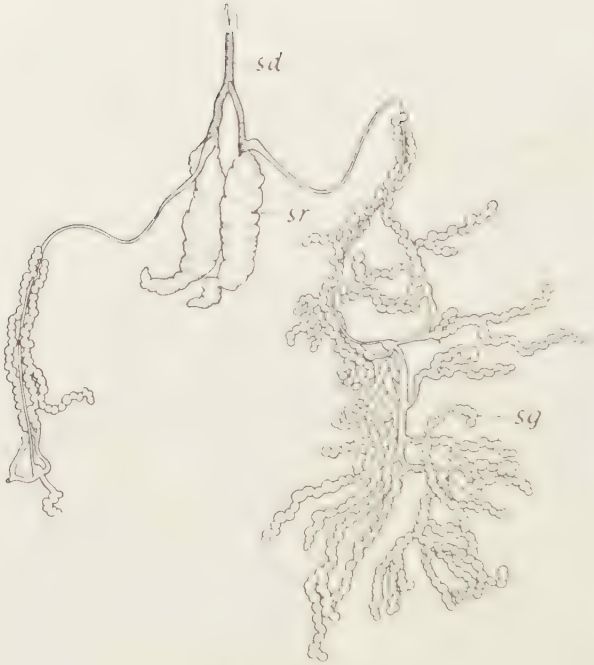
Behind the closing apparatus, the pharynx (p) expands slightly and its wall becomes thick and muscular and is supported by dorsal and ventral muscles. The comparatively narrow lumen can be seen through the walls of the pharynx which passes into the short oesophagus (o). There is no proventriculus, but the oesophagus projects into the lumen of the mid-intestine and there expands into a cup-like valve (ov), the oesophageal or cardiac valve.

The mid gut (m) is relatively long and straight and its diameter varies with its contents. At its posterior end it contracts considerably and the narrowed tube bends at right angles. Immediately anterior to the constriction is the origin of the six malpighian tubules (mp). They arise in two groups of three placed on either side of the mid gut so that their apparent origin is on the mid gut, but this is probably secondary. The malpighian tubules are embedded in the fat-body surrounding the gut. They run forward about half the length of the mid gut and then posteriorly to the hind end of the abdomen, where they again turn forwards and end freely in the abdomen.

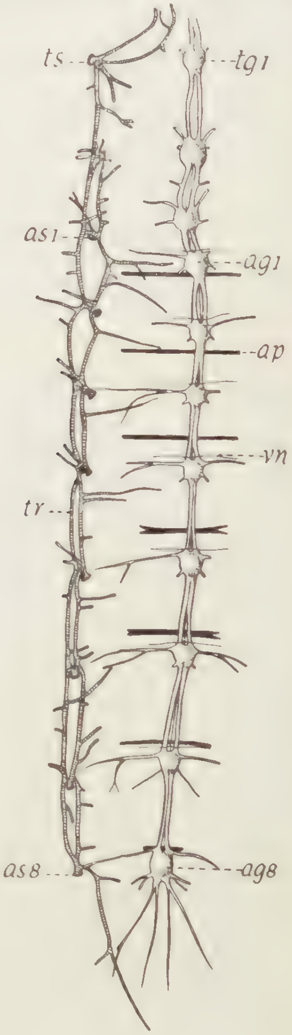


Figs. 1 and 3.—1. *Panorpa* larva, alimentary canal. a = anus, h = hind gut, m = mid gut, mp = malpighian tubules, o = oesophagus, ov = oesophageal valve, p = pharynx, rp = rectal process. 3. *Panorpa* larva, brain and sub-oesophageal ganglion. an = antenna, anl = antennary lobe, b = brain, og = sub-oesophageal ganglion, t = tentorium.

The hind intestine (h) begins immediately posteriorly to the bend in the constricted region of the mid gut. It is separated from the mid gut by a pyloric valve (py), which is represented internally by a short intrusion of the mid gut into the hind gut. Externally the muscular walls of the hind intestine project around the posterior end of the mid gut forming a shallow cup. The hind gut passes forward for a short distance and then bends sharply posteriorly to run to the anus. At its anterior end its walls are much folded and ribbed, but the ribs disappear posteriorly. There is no expansion into a rectum and there are no rectal glands. The gut expands shortly before the anus and lateral muscles are attached to its walls. It is strongly constricted below these muscles and opens into a membranous pouch, out of which also open four conical rectal processes (rp). These are supplied with numerous



2



4

FIGS. 2 and 4.—2. *Panorpa* larva, salivary glands. sd = salivary duct, sg = salivary gland, sr = salivary reservoir. 4. *Panorpa* larva, central nervous system and tracheal system of left side. ag = abdominal ganglion, ap = apodeme, as = abdominal spiracle, tg = thoracic ganglion, tr = trachea, ts = thoracic spiracle, vn = ventral sympathetic system.

muscles which are attached to the walls of the ninth segment. These processes nearly always contain debris of some sort such as sand, earth, etc. The large pouch opens to the exterior at the anus, which is protected by a pair of small flaps and one larger one. The four rectal processes can be evaginated through the anus, in which position they are frequently found when the insect is killed.*

THE SALIVARY GLANDS (fig. 2).

The common salivary duct (sd) opens on the labium and then passes back through the head and divides below the sub-oesophageal ganglion into two short branches. The common duct and its branches are distinguished by strong annular cuticularisation very similar to that found in the larvae of Diptera and closely resembling the spiral thickening of a trachea. Each duct opens into a very thin-walled elongate sac (sr), which is much wrinkled and becomes very narrow before its apex. The fat-body adheres closely to these sacs. The duct continues as a slender tube, which becomes very fine and is covered by the branching chains of cells of the gland. It terminates in a small bell-shaped chamber, out of which open the three tubular glands (sg), which branch again and again into chains of glandular salivary cells. The cells become smaller towards the end of each chain. The cells do not lie end to end, but each slightly to one side of the previous one, so that the chains have a zigzag appearance. The glands are spread out in the fat-body in which they are embedded.

THE CENTRAL NERVOUS SYSTEM (figs. 3 and 4).

The brain or supra-oesophageal ganglion is relatively narrow and lies transversely in the head between the two groups of lateral ocelli (b). The antennary lobes (anl) are on its anterior surface, as are also two stout nerves which pass forwards to the mouthparts. The para-oesophageal connectives are short and are joined above the sub-oesophageal ganglion (og) by a transverse commissure. The sub-oesophageal ganglion is almost hidden by the wide body of the tentorium (t). There are three thoracic and eight abdominal ganglia, the latter lie in the first to the eighth abdominal segments. Each abdominal ganglion sends out, among other nerves, a lateral nerve which passes under two longitudinal muscles and over the remainder to send a branch to the spiracle of its segment. All the connectives between the ganglia are double.

THE OESOPHAGEAL SYMPATHETIC NERVOUS SYSTEM (fig. 5).

The frontal ganglion (fg) lies on the oesophagus, where it widens below and in front of the brain. A fine nerve runs forward along the oesophagus from the frontal ganglion and two lateral nerves join a pair of nerves (fgc) arising from the sub-oesophageal ganglion at the base of the para-oesophageal connectives. The recurrent nerve (rn) runs back along the oesophagus (o) from the frontal ganglion. It lies below the aorta (ao), which is closely attached to the oesophagus by muscles, so that the two run together along the oesophagus for a short distance. The recurrent nerve then branches and the aorta leaves it. The two branches (rn_1) of the recurrent nerve pass back along the oesophagus to the mid gut, where they again branch and ramify.

---

* They were known to most of the authors who described *Panorpa* larvae and were called by Brauer, 1863, the four-pronged balancing fork, by Miyake, 1912, the anal fork and by Shiperovitsh, 1925, the finger-shaped appendages. It was thought that the processes functioned as a leg, which helped the larva to support itself and walk. Shiperovitsh suggested that they have a respiratory function.

They also occur in *Harpobittacus tillyardi* E.P. and in *Bittacus stigmaterus* Say.

THE VENTRAL SYMPATHETIC NERVOUS SYSTEM (fig. 4).

This system is present in connection with the central nervous system as a pair of transverse nerves (vn) in each segment. These nerves unite to form a longitudinal nerve which is connected to the preceding thoracic or abdominal ganglion. They were not observed in the prothoracic or eighth abdominal segment.

RESPIRATORY SYSTEM (fig. 4).

There are two main longitudinal tracheal trunks, a dorsal and a ventral one on either side of the body of the larva. These trunks are connected by short branches to each spiracle; there are one thoracic and eight abdominal spiracles. The thoracic spiracle lies in the prothorax (ts). The spiracles are similar in appearance to those described by Miyake 1912 in *P. nipponensis* Nav. (*P. klugi* of Miyake). There is a small stigmatic cord at the junction of the meso- and metathorax, but no spiracle. A branch is given off by the ventral trunk, just before it reaches the spiracle in each segment. This branch goes to the alimentary canal, where it branches profusely, aerating and also anchoring the intestine. Tracheae from the ventral trunk run to the nerve ganglia of their segments.

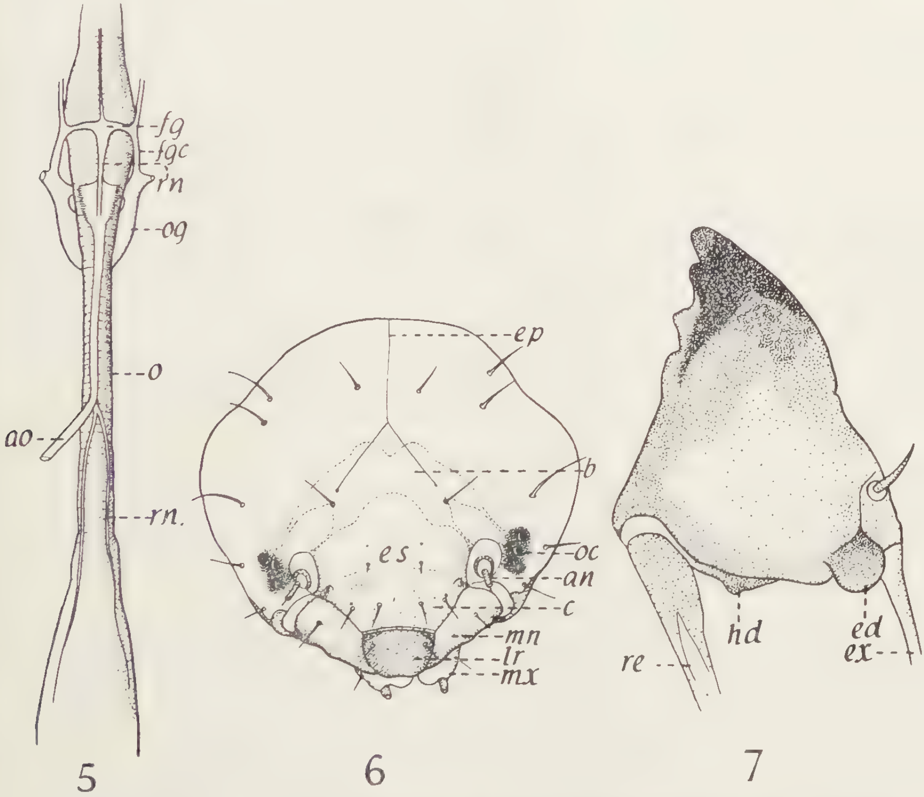
Boreus hyemalis L. larva.

The two descriptions of the external anatomy of this larva by Brauer 1863 and Withycombe 1922 do not agree on one or two points. Brauer states that there is a single ocellus on each side of the head, while Withycombe says that there is a pair laterally, but it is not clear whether this means that there are two or one on each side. There are in fact three ocelli on each side, two distinct and one less so. Both authors state that there is a spinneret on the labium between the labial palps. It will be shown later that this is not so. My observations disagree in other respects with those of these authors on the structure of the mouthparts.

The head of the larva (fig. 6) is comparatively lightly pigmented and it is possible to see the musculature and the brain through the semitransparent cuticle. The epicranial suture (ep) is distinct but its two branches, the frontal sutures, end abruptly about half-way down the dorsal surface of the head. The epistomal suture (es) is distinct. The antennae (an) are two-segmented and the terminal segment bears a long spine. There are three ocelli (oc) arranged in a curve outside the antennae. The part of the head capsule surrounding them is heavily pigmented. The clypeus (c) projects over the bases of the mandibles and the semicircular labrum (lr) covers their apices. Each mandible articulates on its inner side with the head at the junction of the frons and clypeus and on its outer side with the gena at the base of the maxilla (mx). The labrum is indented on its free anterior margin.

Each mandible (fig. 7) is a large triangular appendage. It has a prominent apical tooth and three rather blunt teeth on the inner margin. It is attached by strong ligaments to the extensor (ex) and retractor (re) muscles. The hypocondylus (hd) is large, the epicondylus (ed) less prominent. The mandible is not so sharply toothed as that of the *Panorpa* larva.

The maxillae and labium together form the floor of the mouth (fig. 8). The segments composing them are largely membranous. The maxillae lie on either side of the labium, the stipites being fused with the submentum. Each maxilla bears a palpifer (pf) (which supports a two-segmented maxillary palp (mxp)) and a large lobe (mxl), the fused galea and lacinia or maxillary lobe. This lobe is divided into two areas, an apical one which bears short bristles and a basal one carrying fine hairs. The maxillary lobes are relatively very large and meet one another in the mid line dorsal to the labium. On the ventral surface of each lobe is a shallow groove against which the labial palp (lp) rests. The stipes (st) is long and almost entirely membranous, but it is supported on its inner ventral margin by a narrow sclerotised strut. At the inner base of the stipes is an oval sclerite which is probably the reduced cardo (ca). This maxilla is remarkably similar to that of a caterpillar.

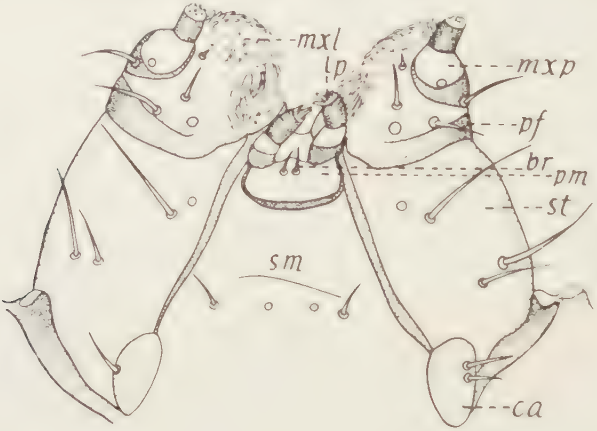


Figs. 5–7.—5. *Panorpa* larva, oesophageal sympathetic nervous system. ao = aorta, fg = frontal ganglion, fgc = frontal ganglion connective, o = oesophagus, og = sub-oesophageal ganglion, rn = recurrent nerve, rn_1 = branch of recurrent nerve. 6. *Boreus hyemalis* L. larva, dorsal view of head. an = antenna, b = brain, c = clypeus, ep = epicranial suture, es = epistomal suture, lr = labrum, mn = mandible, mx = maxilla, oc = ocellus. 7. *Boreus hyemalis* L. larva, left mandible, ventral view. ed = epicondylus, ex = extensor muscle, hd = hypocondylus, re = retractor muscle.

The labium possesses a prementum (pm) in the form of a solid cone, the apex of which lies between the labial palps (lp). The dorsal wall passes below the maxillary lobes, to project into the mouth cavity and support the hypopharynx. The ventral surface of the prementum is supported by a narrow, cuticularised hoop. The two-segmented labial palp (lp) carries on its apex a number of papillae. The submentum (sm) is entirely membranous. The labio-maxillary plate stands out a little way from the base of the head so that the cardines (ca) and the membranous proximal area of the submentum are at an angle with the plane of the plate.

There is no ligula, but on the apex of the prementum, between the labial palps, are two bristles (br), the apices of which converge towards one another. It is the convergence of these bristles which gives them the superficial appearance of a spinneret described by Brauer (1863) and Withycombe (1922).

The salivary duct opens on the hypopharynx and not on the labium.



8

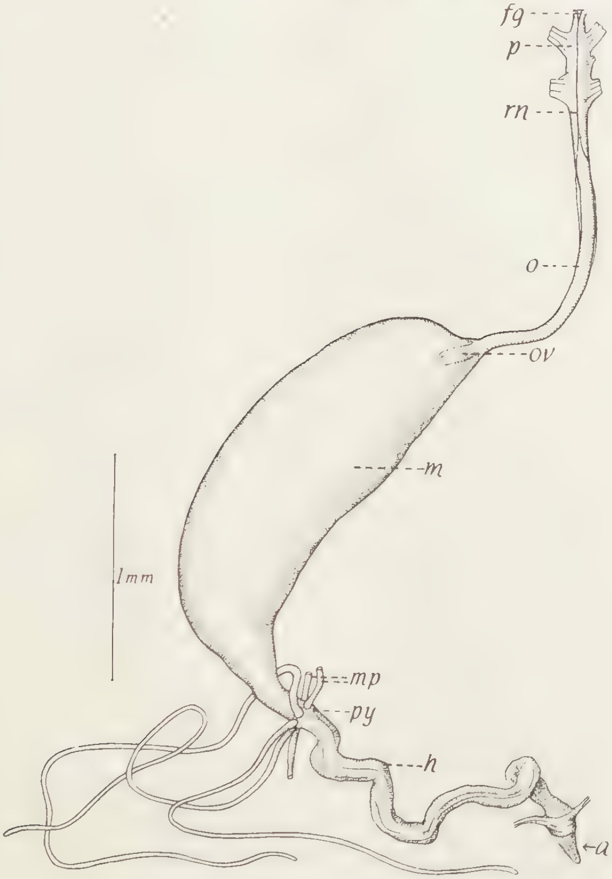
Fig. 8.—*Boreus hyemalis* L. larva, maxillae and labium. br = bristle, ca = cardo, lp = labial palp, mxp = maxillary palp, mxl = maxillary lobe, pf = palpifer, pm = prementum, sm = submentum, st = stipes.

The Internal Anatomy.

Masses of spongy, white fat-body are seen when the larva is opened and pinned out. This fat-body covers the main tracheae, surrounds the hind gut and overlies the salivary glands.

The Alimentary Canal (fig. 9).

This lies in a median position throughout the length of the larva. The pharynx (p) is comparatively short and very muscular and is supported by strong muscles. Anterior to the brain numerous muscles attach it to the head capsule. Between the origins of these anterior muscles is a narrow space on the dorsal surface of the pharynx in which lies the frontal ganglion (fg) of the oesophageal sympathetic nervous system. This ganglion sends a nerve posteriorly along the dorsal surface of the oesophagus (o). The oesophagus passes back through the thorax surrounded by the salivary glands. There is no proventriculus at the junction of the fore and mid gut, such as is found in the adult, but the oesophageal tube is produced into the lumen of the mid gut, forming an oesophageal valve (ov). The mid gut or mesenteron (m) is short and thin walled but very distensible. It is enormously swollen with fragments of moss leaves when the larva is feeding. It narrows towards its junction with the hind gut. At the junction is a muscular constriction or valve (py), and immediately below this arise the six malpighian tubules (mp).



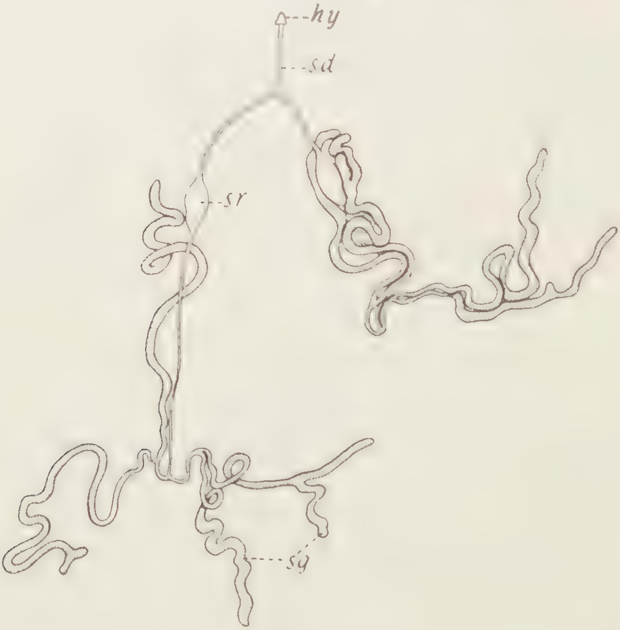
9

FIG. 9.—*Boreus hyemalis* L. larva, alimentary canal. a = anus, fg = frontal ganglion. h = hind gut, m = mid gut, mp = malpighian tubules, o = oesophagus, ov = oesophageal valve, p = pharynx, py = pyloric valve, rn = recurrent nerve.

The tubules are equally spaced around the gut. They are of even thickness throughout their length and lie freely in the abdomen, principally at the posterior end, although some of them pass forwards before returning to the end of the abdomen and surrounding the hind gut. The hind intestine (h) is coiled on itself and is of approximately uniform circumference. The anus is an elongate slit (a). Just before it reaches the anus the gut expands slightly and is surrounded by a circular muscle and supported by lateral muscles. It then expands into a small membranous chamber surrounding the anus. There is no rectal expansion.

THE SALIVARY GLANDS (fig. 10).

The salivary glands are difficult to see in Ringer's solution and were dissected in 70 per cent. alcohol. The salivary glands extend through the body cavity to the posterior end of the mid intestine and are much coiled. Their structure is very similar to that of the adult, with a few minor differences. The common salivary duct, which opens on the hypopharynx (hy), divides into two under the sub-oesophageal ganglion, at the anterior margin of the prothorax. The two ducts (sd) run up on either side of the nerve cord to the oesophagus, where each duct expands into a small thin-walled reservoir (sr), relatively not as large as that of the adult. The fine duct then continues its course to meet the gland (sg), which consists of four tubules which join in pairs before entering the duct. Each tubule of the gland may fork again quite irregularly. As in the adult, one pair of tubes of each gland coils around the duct and reservoir, while the other pair lies among the malpighian tubules on the side of the intestine.

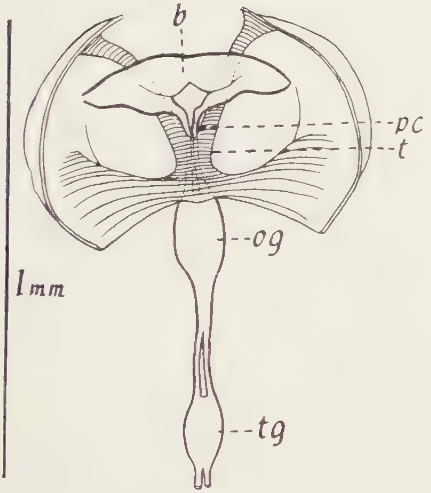


10

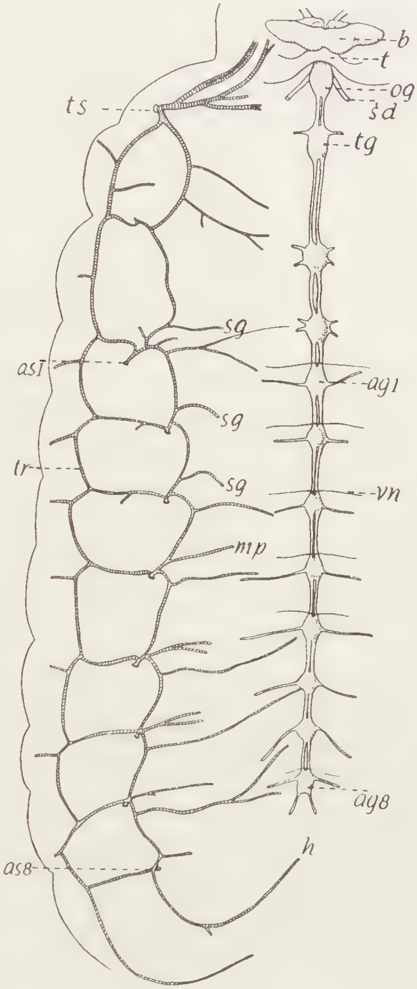
FIG. 10.—*Boreus hyemalis* L. larva, salivary glands. hy = hypopharynx, sd = salivary duct, sg = salivary gland, sr = salivary reservoir.

THE CENTRAL NERVOUS SYSTEM (figs. 11 and 12).

The brain (b) lies transversely in the anterior region of the head, slightly posterior to and between the most dorsal of the ocelli. The brain forks at either side; one lobe passes laterally to the ocelli (the ocellar lobe), and the other (the antennary lobe) projects anteriorly and sends a nerve to the antenna. Below the antennary lobe, the para-oesophageal connective (pc) passes ventrally between the arms of the tentorium (t) and runs under the body of the tentorium to the sub-oesophageal ganglion (og), the anterior end of which lies under the body of the tentorium. The anterior arms of the tentorium diverge only gradually, so that the para-oesophageal connectives have to pass first ventrally and then turn through a right angle to pass between them and so under the body of the tentorium.



11



12

Figs. 11–12.—11. *Boreus hyemalis* L. larva, brain. b = brain, pc = para-oesophageal connective, og = sub-oesophageal ganglion, t = tentorium, tg = thoracic ganglion. 12. *Boreus hyemalis* L. larva, central nervous system and tracheal system of left side. ag = abdominal ganglion, as = abdominal spiracle, b = brain, h = hind gut, mp = malpighian tubule, og = sub-oesophageal ganglion, sd = salivary duct, sg = salivary gland, t = tentorium, tg = thoracic ganglion, tr = trachea, ts = thoracic spiracle, vn = ventral sympathetic nervous system.

The sub-oesophageal ganglion is large and lies partly in the posterior part of the head capsule; the greater part of it, however, is in the prothoracic segment. The lateral space between the dorsal and ventral arms of the tentorium is occupied by the large mandibular muscles.

There are three thoracic ganglia (tg), one in each of the thoracic segments and eight abdominal ganglia (ag). The chain of abdominal ganglia extends from segment one to seven (fig. 12). The connectives are double between all the ganglia.

THE OESOPHAGEAL SYMPATHETIC NERVOUS SYSTEM (fig. 9).

The frontal ganglion (fg) lies on the pharynx immediately anterior to the brain. The recurrent nerve (rn) passes back from the ganglion along the dorsal surface of the pharynx. It forks just behind the brain and its branches lie on either side of the oesophagus passing back to the mid gut.

THE VENTRAL SYMPATHETIC NERVOUS SYSTEM (fig. 12).

This is similar to that of the *Panorpa* larva and consists of a pair of transverse nerves (vn) connected to the preceding ganglia of the central nerve chain by a median nerve. These nerves were not seen in connection with every ganglion, but as they are exceedingly fine and difficult to see they may be present.

The tracheal system (fig. 12) consists of two main tracheal trunks on each side of the body, one dorsal and one ventral, which give off numerous branches to the various organs. The ventral trunk gives off branches to the salivary glands (sg), the malpighian tubules (mp), the nerve cord and also to the intestine. Branches from the dorsal trunk pass to the dorsal regions of the body. Two large tracheae run from the prothoracic spiracle into the head.

There is one thoracic spiracle (ts) situated in the prothorax and a degenerate stigmatic thread terminates between the meso- and metathorax. There are eight abdominal spiracles (ag), one on each of the first eight abdominal segments.*

THE DORSAL VESSEL.

This can be found by dissecting the larva from the ventral surface. It lies between the muscles on the dorsal surface of the body. It is a narrow, transparent-walled tube extending through the length of the body in the mid line. The heart lies close to the dorsal body wall in the abdomen, but the aorta in the region of the oesophageal valve descends and lies along the oesophagus adhering closely to its dorsal surface. Passing forwards, it becomes more and more slender and appears to terminate just before the origin of the large supporting muscles of the pharynx. The heart is lined on either side of its posterior region by a single layer of large cells, the nephrocytes. No chambers are externally visible in the heart.

GENITAL RUDIMENTS.

The rudiments of the reproductive organs were found in fully fed larvae.

Male rudimentary reproductive organs.

Two large globular bodies containing considerable numbers of spongy cells were found lying above the anterior part of the hind intestine. Each of the cells composing the globular body possessed numerous nuclei and when the globular body was opened they emerged as translucent cells dotted with white. These globular bodies were the developing testes and they were connected to one another by a fine thread and to something in the body cavity which it was impossible to determine.

---

* The prothoracic spiracle consists of two circular apertures opening into two short cuticularised tubes leading into the atrium, out of which opens the trachea. Each of the abdominal spiracles consists of a single circular aperture opening into a short tube, which passes back into the trachea. There appears to be a small scar at the side of each spiracle.

Female reproductive rudiments consist of two oval bodies lying on the hind intestine. They were together as large as the swollen mid intestine. Each oval body was composed of eight finger-like units each consisting of a linear series of irregularly shaped cells. The units were united at their posterior ends and appeared to pass into a common duct, which became very slender and was lost in the fat-body attached to the body wall. These units were the developing ovarioles of the insect.

DISCUSSION.

The differences in the anatomy of the two larvae are not as striking as those of the adults.

The salivary glands differ greatly, but while those of the *Panorpa* larva are dissimilar from those of its imago, the glands of *Boreus* are very similar to those of the adult.

The regions of the alimentary canal differ in proportion in the two larvae. The three parts are of about equal length in *Boreus*, but the fore gut of the *Panorpa* larva is relatively very short and the mid gut long. *Boreus* does not have the rectal processes that are found in *Panorpa*.

The nervous system is in general similar, but the para-oesophageal connectives are much longer in *Boreus* and its sub-oesophageal ganglion, as a result, lies partly in the prothorax.

REFERENCES.

BRAUER, F., 1863, Beiträge zur Kenntniss der Panorpiden-Larven. *Verh. zool.-bot. Ges. Wien*, **13** : 307–324, 2 pls.

CARPENTER, F. M., 1931, Revision of Nearctic Mecoptera. *Bull. Mus. comp. Zool.*, **72** : 205–277, 8 pls.

CURRIE, G. A., 1932, Some notes on the biology and morphology of the immature stages of *Harpobittacus tillyardi* E.P. *Proc. linn. Soc. N.S.W.*, **57** : 116–122, 13 figs., 1 pl.

ESBEN-PETERSEN, P., 1929, Neuroptera, Mecoptera. *Danmarks Fauna*, **33** : 134 pp., 90 figs.

FELT, E. P., 1894, The Scorpion Flies. *Rep. New York Ent.*, **10** : 463–480, 2 pls.

MACLACHLAN, R., 1868, A monograph of the British Neuroptera Planipennia. *Trans. ent. Soc. Lond.*, **1868** : 145–224, 5 pls.

MIYAKE, T., 1912, The life history of *Panorpa klugi* M'L. *J. Coll. Agric. Tokyo*, **4** : 117–139, 2 pls.

SETTY, L. R., 1931, The biology of *Bittacus stigmaterus* Say. *Ann. ent. Soc. Amer.*, **24** : 467–484, 1 pl.

SHIPEROVITSH, V. J., 1925, Biologie und Lebenszyklus von *Panorpa communis* L. *Rev. russe. Ent.*, **79** : 27–37, 15 figs.

STEINER, P., 1930, Studien an *Panorpa communis* L. *Z. Morph. Ökol. Tiere*, **17** : 1–67, 41 figs.

STITZ, H., 1926, Mecoptera. *Biol. Tiere Deutsch.* **21** (35) : 28 pp., 44 figs.

SYMS, E. E., 1933, Notes on British Mecoptera. *Trans. Proc. S. Lond. ent. nat. Hist. Soc.*, **1933** : 84–88, 2 pls.

WALDE, K., 1934, Die Lebensgeschichte der Skorpionsfliege (*Panorpa communis*). *Konowia*, **13** : 1–7.

WITHYCOMBE, C. L., 1921, On the life history of *Boreus hyemalis* L. *Trans. ent. Soc. Lond.*, **1921** : 312–318, 3 figs., 1 pl.

KEY TO FIGURES ALPHABETICALLY ARRANGED.

a = anus.
ag = abdominal ganglion.
an = antenna.
anl = antennary lobe.
ao = aorta.
ap = apodeme.
as = abdominal spiracle.
b = brain.
br = bristle.
c = clypeus.
ca = cardo.
ed = epicondylus.
ep = epicranial suture.
es = epistomal suture.
ex = extensor muscle.
fg = frontal ganglion.
fgc = frontal ganglion connectives.
h = hind gut.
hd = hypocondylus.
hy = hypopharynx.
lp = labial palp.
lr = labrum.
m = mid gut.
mn = mandible.
mp = malpighian tubule.
mx = maxilla.
mxl = maxillary lobe.
mxp = maxillary palp.
o = oesophagus.
oc = ocellus.
og = sub-oesophageal ganglion.
ov = oesophageal valve.
p = pharynx.
pc = para-oesophageal connective.
pf = palpifer.
pm = prementum.
py = pyloric valve.
re = retractor muscle.
rn = recurrent nerve.
rn_1 = branch of recurrent nerve.
rp = rectal process.
sd = salivary duct.
sg = salivary gland.
sm = submentum.
sr = salivary reservoir.
st = stipes.
t = tentorium.
tg = thoracic ganglion.
tr = trachea.
ts = thoracic spiracle.
vn = ventral sympathetic nerve.

BOOK NOTICE.

Physiological Genetics. By RICHARD GOLDSCHMIDT. London (McGraw Hill Publishing Co., Ltd.) 1928. pp. ix + 375. Price 24*s*.

This book is arranged in four parts, with a bibliography, author index and subject index.

The subject of the book has been dealt with twice previously by the author, on each occasion in the German language.

The work is addressed to readers with a knowledge of genetics and embryology, and an attempt is made to review all available material and to "organise it into the skeleton of a future science of physiological genetics."

The first part is the introduction in which the scope of the subject is defined. This is followed by the second part entitled: "The mutated gene and the potentialities of development," which is in turn divided into nine chapters, the whole occupying over 250 pages.

Section 3 relates to "The cytoplasm and the activation of the gene," and includes four chapters, and the fourth section on "The nature of the gene" comprises six chapters.

By far the greater amount of the material studied is taken from the Insecta as might be expected, and many of the illustrations relate to insects.

The bibliography is full and extensive; it occupies some 50 pages, and is alphabetically arranged.

The book is published in the well-known series "McGraw Hill Publications in the Zoological Sciences."

BOOK NOTICE.

Evolution out of doors. A study of sex differences and animal coloration. By H. J. C. MOLONY, edited and with an appendix by J. R. DE LA H. MARETT. pp. xx + 248, 25 pls. 8vo. London: Hutchinson & Co. Price 15*s*.

This book contains 18 chapters and an appendix and is completed by a short bibliography. There is no index. The opening chapters are devoted to a discussion on colour in the animal kingdom, its laws, uses, and effect. This is followed by chapters on sexual marks and marks of recognition and leadership. The examples quoted in these 13 chapters are almost all taken from mammals and birds. Chapter 14 is concerned with the colours of flowers; Chapter 15 with mutations; Chapter 16 with mimicry, including mimicry in insects; Chapter 17 with parasitism, but not insect parasitism; and Chapter 18 with sex, combat and the ascent of man.

The appendix by J. R. de la H. Marett is concerned with accelerators of evolution and adaptational polyvalence.

BOOK NOTICE.

Basic German for Science Students, with vocabulary and English translations of the German passages. Third edition. By M. L. BARKER. pp. xiii + 186. 8vo. Cambridge: W. Heffer. 1937. Price 6*s*.

The scope of this book is expressed in its title. It comprises two parts, the first "General passages for acquiring the basic vocabulary" and the second "Scientific passages." A vocabulary extending to 30 pages is given and in two appendices are printed the German passages set in science degree examinations in the University of Edinburgh from 1923 to 1932, and in the University of London from 1928 to 1936.

The book is intended for science students and the passages given deal with Chemistry, Zoology, Botany, Physics, Mathematics and Medicine.

BOOK NOTICE.

Methods for the study of the internal anatomy of insects. By C. H. KENNEDY. Second Printing 1932. Mimeographed. Columbus, Ohio. (The Author.) pp. 103. Price $2.00.

This work is written for the beginner with no knowledge of microtechnique, who is anxious to study the internal anatomy of insects.

The book is divided into 15 sections, completed by an index of 10 pages printed in double column. Each section is devoted to a specific subject as, for instance, Collection and dissection of fresh material, Preparation of whole mounts, Embryological technique, Concerning illumination, Drawing and the making of illustrations, to mention but a few.

Full details, with quantities of materials required, are given for all processes described.

BOOK NOTICE.

Traité d'Entomologie médicale et vétérinaire. Par M. NEVEU-LEMAIRE. Paris (Vigot Frères). pp. xxvii + 1339, 597 figs. 1938. Price 250 francs.

This book is the continuation of a work on Zoology and Parasitology of which the first volume, devoted to Helminthology, was published in 1936 by the same author.

The book is planned in four parts, the first being devoted to general entomology; the second to special entomology; the third comprises a list of the hosts of parasitic and commensal Arthropods, and the fourth and last a list of parasites and pathogenic germs, of which an Arthropod is the intermediate host or vector.

Throughout the work the term entomology is understood in its very widest sense, so that the first section is in fact concerned with Arthropoda.

Part 2 opens with a chapter on the Crustacea and reaches the true insects after dealing with Pentastomids, Arachnoids and Myriapods.

The true insects require nearly 700 pages with some 350 figures for their treatment.

In the part devoted to special entomology a systematic arrangement of the Insecta is used. Under each order is a key to the sub-orders, with in turn keys to the families and, where necessary, keys to the genera are given and liberal illustrations of species are supplied.

Under the species mentioned details of morphology, habitat, biology, geographical distribution, pathology, and transmission of pathogenic agents are given in detail.

The third part, devoted to lists of hosts, is concerned with man and domestic animals. In it the parasites of each species are listed systematically and indication is given of the location of the parasite on the host.

The fourth part lists organisms of which Arthropods are intermediate hosts or vectors.

A select bibliography and an index occupying 45 pages printed in treble column complete the work.

BOOK NOTICE.

Statistical methods applied to experiments in agriculture and biology. By G. W. SNEDECOR. pp. xv + 341. 8vo. Ames, Iowa (Collegiate Press, Inc.).

This book is not only addressed to the mathematician and statistician, but "it is a fundamental belief of the author that statistical method can be used competently by scientists not specially trained in mathematics." For this reason, and because the book is obviously intended for practice rather than theory, "the classical theory of large samples receives scant attention. In most places where it is mentioned at all it is introduced as a simplified special case of the small sample."

The book is arranged in a "developmental" order with the elementary ideas placed first and only one new concept presented at a time.

An outline of the elements of statistical method is given as follows: Attributes; Individual comparisons; Group comparisons; Short cuts; Regression; Correlation; Analysis of variance, single criterion of classification; Analysis of variance, two criteria of classification, and the 16 chapters of the book follow this order.

BOOK NOTICE.

Les Arachnides de France. Par EUGENE SIMON. Tome 6, Pte 5. Oeuvre posthume publié par L. Berland et L. Fage. pp. 979–1298, 526 figs. 8vo. Paris. (Edgar Malfère.) 1937.

This fifth part of the sixth volume of Simon's classic work on the spiders of France completes a work the first volume of which appeared in 1874.

It contains the completion of the general synopsis and catalogue of the French species, and concludes the whole work, although Volume 7 was published already in 1879.

The text is as it was written by Simon, but the illustrations are by MM. Berland and Fage, and Volume 6 has required nearly a quarter of a century for its publication. The dates of publication of the whole work are printed on page 1298.

An index by A. Bonnet extending to 24 pages in double column completes the volume.

The work is arranged in a series of keys commencing with subfamilies and concluding with species. A catalogue of each family is given at the end of the keys.

BOOK NOTICE.

Die Grossschmetterlinge Südhannovers besonders der Umgebung Göttingens. Von KARL FINKE. Herausgegeben von der Göttinger Vereinigung Naturforschender Freunde. pp. iv + 120. 8vo. Göttingen, 1938. (In Kommission bei Dr. Ludwig Häntzschel & Co. K.G.) Price Rmk.4.80.

This booklet deals with the Macrolepidoptera of the region of South Hannover, especially the district round Göttingen.

It comprises an introduction, giving the limits of the region dealt with, remarks on the changes in the fauna during the last fifty years, list of literature consulted and the list of almost 800 species now recorded from South Hannover.

The arrangement of the insects is that of the Staudinger-Rebel Catalogue of 1901, and the serial numbers of that catalogue are utilised. Similarly separate indices are given for families and genera and for species and lower categories. In the indices reference is to the catalogue numbers and not to the page of the book.

Under the species name is given also the German popular name, and available information as to time of appearance, breeding habits and, occasionally, details to assist in rearing in captivity.

BOOK NOTICE.

New bilingual catalogue of the British Lepidoptera. By I. R. P. HESLOP. pp. 131. 4to. London. 1938.

This book is " a classified and indexed list of the latin and english names of British Butterflies and Moths, ... ", which the author has published in a desire to record " the non-revised scientific nomenclature which is still the normal currency among the great majority of Entomologists, before it is entirely superseded by revised nomenclature."

The author has traced in the literature English names for 1024 of the 1084 species of " Macrolepidoptera " listed in his book. These names he gives in a tabulated form arranged under the 8 " classes," Papiliones, Sphinges, Bombyces, Noctues, Geometres, Pyrales, Psyches, Micropteryges.

The tables give subfamily, generic and specific names, followed by the English name, the whole being systematically arranged by families.

Book Notice.

Faunistischer Führer durch die Coleopteren-Literatur. Die wichtigste Käfer-Literatur nach geographischen Gebieten geordnet. Von S. Schenkling. Band I. Europa. Lieferung 1–2, pp. 1–128. 8vo. Neubrandenburg (Verlag G. Feller). Subscription Price Rmk. 6.00 per Lieferung.

This indispensable work has at last begun to appear and commences with the literature of Coleoptera of the Palaearctic Region. It is anticipated that the work will comprise 4 volumes, devoted to Europe, Palaearctic Africa and Asia and the Indomalayan Region, the Ethiopian Region and Australia and Oceania, and America.

Lieferung 1 deals with the literature of the Palaearctic Region in general and Lieferung 2 with that of Europe in general and the commencement of the literature of the Scandinavian countries.

The entries are arranged with catalogues first, followed by works on Coleoptera in general, and finally on families and genera. Marginal notes attract attention to the special entries under main sections.

It is anticipated that a period of two years will be required for publication.

Book Notice.

La vie des Mouches et des Moustiques. Par E. Séguy. "Bibliothèque Juventa." 8vo. Paris. (Librairie Delagrave.) 1938. pp. 254, 22 pls. (4 col.). Price 16.00 francs.

This popular book is divided in three parts: 1 Flies, 2 Mosquitos, 3 Utility of Flies and Mosquitos.

The chapters of Part 1 are concerned with: oviposition and eggs; larvae; adults; hibernation; invasions of flies; biting flies. Those of Part 2 with: oviposition and eggs of mosquitos; larvae and nymphs; adults; biology of mosquitos; malaria; yellow fever; filariasis and dengue; protection against mosquitos; and natural enemies of mosquitos. The whole of Part 3 is devoted to the uses of flies and mosquitos.

Book Notice.

Animal life in fresh water. A guide to British fresh-water invertebrates. By Helen Mellanby. 8vo. London (1938). (Methuen & Co., Ltd.) pp. viii + 296, 211 figs. Price 8*s*. 6*d*.

This book describes all the forms of fresh-water invertebrates commonly found in Britain, together with their life histories and distribution.

It is written in elementary terms and assumes the minimum knowledge of structure and classification on the part of the reader.

Two chapters, filling over 100 pages, are devoted to Insects, the remaining twelve being devoted each to an order of invertebrates. At the end of each chapter or section is given a select list of books for further reference, with short annotations.

The animals are dealt with family by family, and, in those cases where the family contains many representatives in Britain, a further subdivision by genera is made. All available information as to habits and life history is given.

An index completes the book.

PUBLICATIONS

The Publications of the Royal Entomological Society are *Transactions* and *Proceedings.*

The *Transactions* form an annual volume, each paper in the volume being issued as a separate part. The parts are issued irregularly throughout the year.

The *Proceedings* are issued in three series:

Series A. General Entomology
Series B. Taxonomy
Series C. Journal of Meetings

Series A and B are issued in twelve parts, forming an annual volume of approximately 240 pages.

The following information is supplied for the guidance of authors wishing to submit papers for publication in any of the Society's journals.

INTRODUCTORY

The Society is prepared to undertake the provision of a reasonable number of text figures. The original drawings for such figures must be supplied by authors. Such drawings or groups of drawings must be drawn to a scale which will permit of their reduction to an area of dimensions not exceeding $7\frac{1}{2} \times 4\frac{3}{4}''$. In the case of the *Proceedings Series A* and *Series B*, authors are required to pay for the necessary blocks for the provision of plates, half-tone and coloured work.

A uniform method is adopted for the citation of bibliographical references in the Society's publications as follows:

> Smith, A., 1936, New species of Coccidae, *Proc. R. ent. Soc. Lond.* (B) **6** : 301–306, pl. 1.
>
> ——. 1936, New species of Coccidae, *Trans. R. ent. Soc. Lond.* **84** : 901–936.

Titles of periodicals cited are to be abbreviated in the manner indicated in the *World List of Scientific Periodicals, 2nd edition,* 1934.

Authors are entitled to receive 25 copies of their papers free of charge and may purchase additional copies provided that request be made before publication.

Papers offered for publication should be sent to the Secretary, Royal Entomological Society of London, at *41, Queen's Gate, London, S.W.7,* and must be typewritten on one side of the paper only. Sufficient space must also be left between the lines for editorial corrections.

The copyright of the Society's publications is vested in the Society.

TRANSACTIONS

Papers offered for publication in the *Transactions* are considered by the Publication Committee of the Society, which meets usually in the months of May and November. In order that papers may be considered at these meetings it is necessary for the manuscript and drawings for any illustrations to be in the hands of the Secretary fourteen days before the meeting of the Committee.

Papers of less than eight printed pages (approximately 7000 words) will not normally be accepted for the *Transactions*, and papers by authors who are not Fellows of the Society must be communicated by a Fellow.

PROCEEDINGS SERIES A AND SERIES B

Papers submitted for publication in either *Series A* or *Series B* of the *Proceedings* by authors who are not Fellows of the Society may be accepted if they are communicated by a Fellow. Preference will be given to papers written in the English language, and papers of more than eight printed pages (7000 words) will not normally be accepted for publication in these journals.

PROCEEDINGS SERIES C

Series C is issued prior to every General Meeting. It contains abstracts of exhibits to be shown and communications to be made, together with the titles of papers accepted for publication.

The annual subscription to *Series A. General Entomology* is *£1 4s. od.; Series B. Taxonomy, £1 4s. od.* (single parts *3s. od.*); and *Series C. Journals of Meetings, 6s. od.*

As from January 1936 the journal *Stylops* is continued as *Proceedings Series B. Taxonomy.* Copies of volumes 1–4 are available at *£1 16s. od.* each, post free

MEETINGS

TO BE HELD IN THE SOCIETY'S ROOMS

41, Queen's Gate, S.W.7

1938.

WEDNESDAY,	November 2	6.0 p.m.	
,,	,, 16	8.0 p.m.	
,,	December 7	6.0 p.m.	

1939.

WEDNESDAY,	January 18	8.0 p.m.	(ANNUAL MEETING)
,,	February 1	6.0 p.m.	
,,	March 1	8.0 p.m.	
,,	,, 15	6.0 p.m.	

THE ROYAL ENTOMOLOGICAL SOCIETY OF LONDON

The Fellowship and Fees

Fellows pay an Admission Fee of £3 3*s*. The Annual Contribution of £2 2*s*. is due on the first day of January in each year, and is payable in advance. Fellows under the age of 25 years may pay the entrance fee in three equal annual instalments.

Fees should be paid to the Treasurer, at 41, Queen's Gate, S.W.7, and *not to the Secretary*.

Fellows desiring to pay their Annual Contribution through their bankers may obtain an official form of banker's order by applying to the Treasurer.

Fellows whose Contributions for the current year have been paid are entitled to receive the *Transactions* and *Proceedings* of the Society free of charge. Further copies may be purchased at reduced prices by applying to the Registrar.

Forms of application for Fellowship, copies of the Bye-Laws and the List of Fellows may be obtained from the Registrar.

Meetings and Exhibitions

Fellows and others wishing to make a communication to a General Meeting of the Society are requested to send in their names, the title of their exhibit, and a short abstract of their remarks, to the Registrar fourteen days before the meeting at which it is proposed to make the communication. Should it be desirable to publish a fuller account of the communication the manuscript may be submitted for publication in *Proceedings Series A* or *Series B*. If the epidiascope is required, 24 hours' notice must be given. Objects for projection should not exceed 6 ins. by 6 ins.

Fellows resident abroad, or otherwise unable to attend meetings, are reminded that notes or observations sent to the Secretary may be communicated to a General Meeting on their behalf.

PRINTED FOR THE SOCIETY BY RICHARD CLAY AND COMPANY, LTD.,
BUNGAY, SUFFOLK.